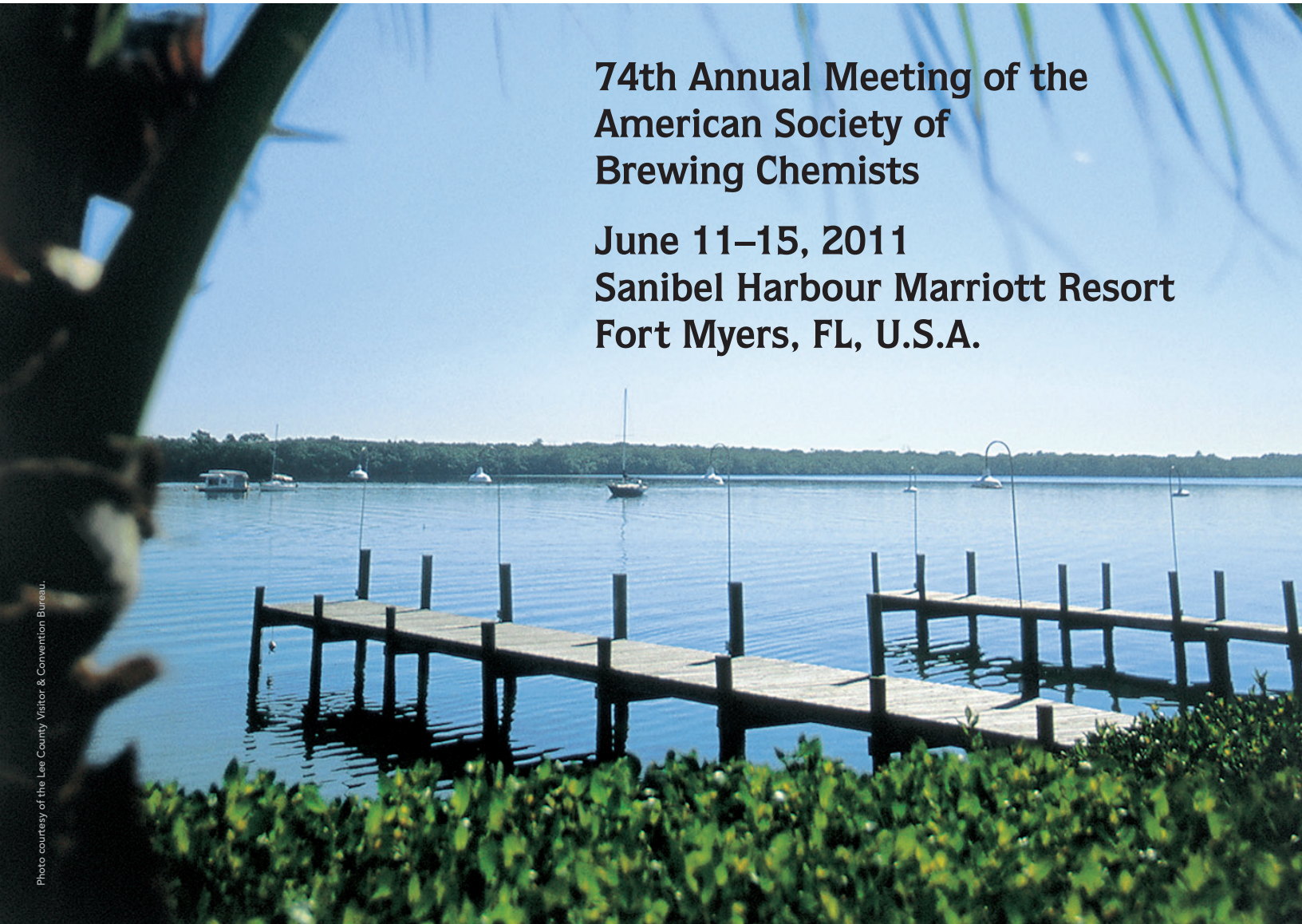
# Beer: A Matter of Science and Perception



**74th Annual Meeting of the American Society of Brewing Chemists**

**June 11–15, 2011**
**Sanibel Harbour Marriott Resort**
**Fort Myers, FL, U.S.A.**

Photo courtesy of the Lee County Visitor & Convention Bureau.

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# *"It's these changes in latitudes, changes in attitudes…"*

– Jimmy Buffett

*Jeff Cornell*

On behalf of the Program Committee, welcome to the 74th Annual Meeting of the American Society of Brewing Chemists! This is the first time our meeting has been in Fort Myers, Florida, nicknamed the "City of Palms." Our meeting location is right on the Intercoastal Waterway right across from Sanibel Island, making it a perfect place to get away from the daily grind (brewing pun intended) and to really focus on *The Science of Beer*.

This year, several elements of the program came together to create our theme, *Beer: A Matter of Science and Perception*. ASBC meetings draw many of the best brewing scientists from around the world to present their work and share their knowledge. But scientific research applied to beer and brewing is rarely black or white. Part of that "gray" area involves another science – perception. The way we perceive things touches our professional lives on a daily basis, whether it's a sensory evaluation of beer or how we go about solving problems. So to explore these areas further, the program features two outstanding speakers: Jeannine Delwiche on "Impact of Multimodal Sensory Input on Perception of Beer Flavor," and Karl Siebert on "Changing Paradigms." Also on the perception theme, you'll find a pre-meeting short course addressing the many aspects of beer haze and colloidal stabilization and a sensory workshop focused on mouth-feel, one of the lesser discussed aspects of beer flavor evaluation.

Also in the line-up is a second pre-meeting short course on "Enzymes in Brewing" and two other exciting workshops during the week: "Breeding Success," featuring advances in barley breeding and malting and "The Wonderful World of Whiskies," continuing our ever-popular exploration of the world of distilled spirits.

Of course the heart and soul of our meeting is the content provided by our oral and poster presenters. I can't tell you how impressed I am with the quality and quantity of the submissions. We have 46 oral presentations in 10 technical sessions as well as 30 posters and I want to thank all of the authors and encourage all of you to submit your work to the *Journal of the ASBC*, the top-rated journal in brewing science. We also have a record number of Technical Subcommittees that have worked tirelessly throughout the year, have accepted several new methods for publication, and will share their results in meetings spread throughout the program. Your participation in these forums is critical and makes our society stronger!

And speaking of methods, don't miss our front-to-back demonstration and tour of the new online *ASBC Methods of Analysis*. If you've been curious about how this advancement will greatly increase the value to you and your organization, please join us for the special session devoted to the online MOA.

We asked for your feedback from previous meetings, and we heard you! Despite a full agenda, we tried our best to avoid concurrent technical sessions. We will also continue to feature the New and Alternative Methods of Analysis and the Emerging Issues sessions scheduled without any competing talks. A lively, point counter-point debate is not to be missed as Pearls of Wisdom returns featuring Charlie Bamforth and Graham Stewart. Last but not least, our exploration of beer and food pairings continues at the Monday luncheon and our popular open forum What's the Buzz? returns as one of the key ways the Program Committee and the Board of Directors hears directly from you – ASBC's most valuable asset!

Cheers,

Jeff Cornell
Program Committee Chair

# Discover the All NEW 14th Edition *ASBC Methods of Analysis*

The new *ASBC Methods of Analysis* is entirely online! Now everyone at your company can have instant access to the updated and upgraded 14th Edition.


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Sign up during the Annual Meeting for introductory savings, and lock that price in for 3 years!

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Brewing Chemists

Make sure your company takes advantage of a major limited-time online upgrade offer. **Order your subscription today for introductory savings that last for 3 years! www.asbcnet.org/moa**

**Learn more at the ASBC Annual Meeting**
Learn more about the 14th edition of the *ASBC Methods of Analysis* on Wednesday, June 15, 2011, at 8:00 a.m. in Island Room. Discover how to improve the quality practices at your company through more effective use of this new online tool. Stops on the virtual tour will include a video demonstration, tutorials on statistics and EPR, and a sampling of more than 70 online calculators.

#8561-5/2011

# Schedule-at-a-Glance

| | | |
|---|---|---|
| **Saturday, June 11** | | |
| 8:00 a.m. – 5:00 p.m. | Board of Directors Meeting and Lunch • Jasmine | |
| 1:00 – 5:00 p.m. | **Short Course:** Haze and Colloidal Stabilization* • Cypress | **Short Course:** Enzymes in Brewing—Theory and Practical Consideration* • Orchid |
| 6:00 – 6:30 p.m. | Meeting Orientation and Mixer • Azalea | |
| **Sunday, June 12** | | |
| 8:00 – 9:30 a.m. | **General Session & Opening Keynote:** Impact of Multimodal Sensory Input on Perception of Beer Flavor, Jeannine Delwiche, PepsiCo • Caloosa Ballrom | |
| 9:45 – 11:00 a.m. | **Technical Session:** Fermentation I • Caloosa Ballroom | |
| 11:00 a.m. – 12:00 p.m. | Technical Subcommittee Meetings • *See program for details* | |
| 12:00 –1:00 p.m. | Technical Committee and Subcommittee Chair Lunch • Hibiscus | |
| 1:00 – 3:00 p.m. | **Workshop:** Beer has Feelings, Too! • Island | **Technical Session:** Malting and Cereal Science I • Caloosa Ballroom |
| 3:00 – 5:30 p.m. | **Exhibits, Posters, and Hospitality** (Authors Present 4:30 – 5:30 p.m.) • Palms Ballroom | |
| 5:30 – 6:15 p.m. | **Pearls of Wisdom** • Caloosa Ballroom | |
| 7:00 – 9:30 p.m. | Welcome Reception • Palms Pool Deck | |
| **Monday, June 13** | | |
| 7:00 – 8:00 a.m. | Speaker Breakfast: All Oral and Poster Presenters • Island | |
| 8:00 – 9:15 a.m. | **Technical Session:** Health Topics in Brewing • Caloosa Ballroom | |
| 9:20 – 10:00 a.m. | **ASBC Guest Lecturer:** Changing Paradigms, Karl Siebert, Cornell University • Caloosa Ballroom | |
| 10:00 – 11:00 a.m. | Technical Subcommittee Meetings • *See program for details* | |
| 10:00 a.m. – 12:00 p.m. | **Exhibits, Posters, and Hospitality** (Authors Present: Even Numbers 11:00 – 11:30 a.m., Odd Numbers11:30 a.m. – 12:00 p.m.) • Palms Ballroom | |
| 12:15 – 1:30 p.m | Food and Beer Pairing Lunch • Everglades Ballroom | |
| 1:45 – 4:30 p.m. | **Technical Session:** Yeast and Microbiology • Caloosa Ballroom | |
| 4:30 – 6:00 p.m. | **Workshop:** The Wonderful World of Whiskies* • Island | |
| **Tuesday, June 14** | | |
| 8:00 – 10:45 a.m. | **Technical Session:** Analytical • Caloosa Ballroom | |
| 10:45 – 11:30 a.m. | **Emerging Issues** • Caloosa Ballroom | |
| 11:30 a.m. – 12:30 p.m. | Technical Subcommittee Meetings • *See program for details* | |
| 11:30 a.m. – 12:30 p.m. | Lunch Available in the Exhibit Hall • Palms Ballroom | |
| 11:30 a.m. – 1:30 p.m. | **Exhibits, Posters, and Hospitality** (Authors Present: Odd Numbers 12:30 – 1:00 p.m., Even Numbers 1:00 – 1:30 p.m.) • Palms Ballroom | |
| 1:40 – 3:20 p.m. | **Technical Session:** Sensory and Stability • Caloosa Ballroom | |
| 3:25 – 5:30 p.m. | **Technical Session:** Hops I • Caloosa Ballroom | |
| 3:30 – 5:30 p.m. | **Workshop:** Breeding Success • Island | |
| **Wednesday, June 15** | | |
| 8:00 – 8:40 a.m. | Demonstration of the Online *ASBC Methods of Analysis* • Island | |
| 8:40 – 10:20 a.m. | **Technical Session:** Fermentation II • Caloosa Ballroom | |
| 10:35 – 11:35 a.m. | New and Alternate Methods of Analysis • Caloosa Ballroom | |
| 11:45 a.m. – 1:15 p.m. | Publications Committee Meeting and Lunch • Hibiscus | Program Committee Meeting and Lunch • Azalea |
| 1:30 p.m. – 3:35 p.m. | **Technical Session:** Hops II • Island | **Technical Session:** Malting and Cereal Science II • Caloosa Ballroom |
| 4:00 – 5:15 p.m. | **Closing Session:** What's the Buzz? • Caloosa Ballroom | |
| 7:00 – 10:00 p.m. | Closing Reception • Everglades Ballroom | |

** Additional registration or ticket is required.*

*ASBC staff will take photos throughout the meeting for use in promotional materials. By virtue of your attendance, you agree to ASBC's use of your likeness in said promotional materials.*

# Program

## Friday, June 10

| | | |
|---|---|---|
| 8:00 a.m. – 5:00 p.m. | Technical Committee Meeting and Lunch<br>(Lunch in The Cove Restaurant) | Cypress |

## Saturday, June 11

| | | |
|---|---|---|
| 8:00 a.m. – 5:00 p.m. | Board of Directors Meeting and Lunch | Jasmine |
| 1:00 – 5:00 p.m. | Short Course: Haze and Colloidal Stabilization* | Cypress |
| 1:00 – 5:00 p.m. | Short Course: Enzymes in Brewing—Theory and Practical Consideration* | Orchid |
| 2:00 – 5:00 p.m. | Exhibit/Poster Set-Up | Palms Ballroom |
| 2:00 – 5:00 p.m. | Registration | Registration 3 |
| 4:00 – 11:00 p.m. | Hospitality | Gardens Ballroom |
| 6:00 – 6:30 p.m. | Meeting Orientation and Mixer | Azalea |

** Additional registration required*

## Saturday Highlights

### Enzymes in Brewing—Theory and Practical Considerations*

*David Maradyn, Novozymes North America, Inc., Franklinton, NC; Alex Speers, Dalhousie University, Nova Scotia, Canada; TBA*

Course Fee: $175

Life, whether plant or animal, involves a complex network of enzymatic reactions. The brewing process is also based on a myriad of enzymatic activities without which the brewing of beer would not be possible. For example, the purpose of malting barley is to allow for the endogenous enzymes in the grain to become activated and for new enzymes to be created. These enzymes are needed to convert starch into sugars for yeast metabolism, degrade complex proteins into simple amino acids for yeast nutrition, and breakdown and solublize plant cell-wall materials. This short course will start with a review of endogenous enzymes in the brewing process: what they are, where they come from, and why they are important in the brewing of beer. The next topic will cover practical aspects, considerations, and learnings from the use of exogenous enzymes in a brewery setting. The third topic will cover new and novel applications of exogenous enzyme use: brewing with high inclusion of adjunct materials, brewing with nontraditional raw materials, reducing fermentation time, increasing flavor stability, and improving colloidal stability. Lectures will be given by active members of the brewing community working in academia, breweries, and allied industries. At the conclusion of the lectures, time will be allocated for a forum-style question-and-answer session to give participants the opportunity to ask additional questions they may have about aspects of enzymes in brewing.

### Haze and Colloidal Stabilization*

*Karl Siebert, Cornell University, Geneva, New York; Al Worley, optek-Danulat, Inc., Germantown, WI*

Course Fee: $175

Haze in beer can have a number of causes. Most frequently it is due to protein–polyphenol interaction, and brewers normally treat beer to delay haze formation beyond the intended product shelf life. Because consumers are more certain of what they see than of what they taste, the presence of haze can make a lasting negative impression. This short course will cover the physics of light scattering (suspended particles, colloids, and light deflection), the chemistry of haze particles (proteins, polyphenols, and other causes), laboratory and in-line haze measurement (scattering angles, filters, wavelengths, and calibration), human visual perception of turbidity (thresholds and above), stabilization of beer to prevent or delay haze formation (cold conditioning, fining, adsorbents, and enzymes), and production of beers with stable clouds.

### Meeting Orientation and Mixer

Grab a beer, meet other attendees, and learn what you can do at the ASBC Annual Meeting. Rub elbows with and have your questions answered by active members of ASBC. First-time attendees and students will gain the most from this event. The meeting orientation and mixer is free, but please indicate your intent to attend when registering.

## Sunday, June 12

| | | |
|---|---|---|
| 7:30 a.m. – 5:00 p.m. | Registration | Registration 3 |
| **8:00 – 9:30 a.m.** | **General Session & Opening Keynote**<br>Impact of Multimodal Sensory Input on Perception of Beer Flavor<br>Jeannine Delwiche, PepsiCo | Caloosa Ballrom |
| 9:00 a.m. – 1:00 p.m. | Exhibit/Poster Set-Up | Palms Ballroom |
| 9:30 – 9:45 a.m. | Break | Palms Garden Foyer |
| 9:30 a.m. – 4:30 p.m. | Silent Auction Open | Palms Garden Foyer |
| **9:45 – 11:00 a.m.** | **Technical Session I – Fermentation I**<br>*Moderator: Chris Powell, University of Nottingham, United Kingdom*<br>9:45 a.m. O-1. F. Methner. Formation of styrene and the aroma compounds 4-vinyl guaiacol and 4-vinyl phenol by top-fermenting wheat beer yeast<br>10:10 a.m. O-2. A. Macintosh. A comparison of small-scale fermentability assays to industrial-scale fermentations<br>10:35 a.m. O-3. M. Nedjma. Maltotriose fermentation by beer yeast induction of the maltotriose transporter byselected yeast strains and the maltose maltotriose medium during propagation | Caloosa Ballroom |
| 11:00 a.m. – 12:00 p.m. | Technical Subcommittee Meetings<br>• International Beer Soluble Iron<br>• Miniature Fermentation Assay/ATP for Water and Rinse Water Hygiene<br>• GC-FID Analysis for Beer Volatiles/Volatile Aldehydes in Beer by SPME-GC/MS | <br>Island<br>Azalea<br>Periwinkle |
| 11:00 a.m. – 1:00 p.m. | Lunch on Your Own | |
| 12:00 – 1:00 p.m. | Technical Committee and Subcommittee Chair Lunch | Hibiscus |
| **1:00 – 3:00 p.m.** | **Workshop: Beer has Feelings, Too!** | Island |
| **1:00 – 3:05 p.m.** | **Technical Session II – Malting and Cereal Science I**<br>*Moderator: Mary-Jane Maurice, Malteurop North America, Milwaukee, WI*<br>1:00 p.m. O-4. K. Siebert. Chemometric investigation of barley and malt data<br>1:25 p.m. O-5. A. Faltermaier. Modifying the malting conditions of common wheat (*Triticum aestivum* L.) by using response surface methodology to ensure processability for brewing purposes<br>1:50 p.m. O-6. E. Eck. Effects of fungal contamination of barley malt on yeast in suspension during fermentation<br>2:15 p.m. O-7. P. Oliveira. Impact of the infection of *Fusarium culmorum* on the ultrastructure and mycotoxin content of malted barley<br>2:40 p.m. O-8. M. Schmitt. Malting extremely small quantities of barley | Caloosa Ballroom |
| **3:00 – 5:30 p.m.** | **Exhibits, Posters, and Hospitality** (Authors Present 4:30 – 5:30 p.m.) | Palms Ballroom |
| **5:30 – 6:15 p.m.** | **Pearls of Wisdom** | Caloosa Ballroom |
| 7:00 – 9:30 p.m. | Welcome Reception | Palms Pool Deck |
| 9:00 – 11:00 p.m. | Hospitality | Gardens Ballroom |

## Sunday Highlights

### Opening General Session and Keynote

#### Impact of Multimodal Sensory Input on Perception of Beer Flavor

*Jeannine Delwiche, PepsiCo, Purchase, NY*

*Jeannine Delwiche*

The theme of the 2011 ASBC Annual Meeting is *Beer: A Matter of Science and Perception*. With her extensive background in sensory and perception science, Jeannine Delwiche, Research Fellow LTR at PepsiCo, will offer her insights to set the stage for the meeting. She will share her own and others' research to show the role of cross-modal perception and how beer appearance, temperature, and mouthfeel can influence perceived flavor. This intriguing area touches many areas relevant to the science of beer, including product design, color, foam quality, aroma, and flavor.

#### Beer Has Feelings, Too!

*Teri Horner, MillerCoors, Golden, CO*
*Jeannine Delwiche, PepsiCo, Purchase, NY*

This workshop will get you thinking about an often neglected part of the beer flavor wheel—mouthfeel. As part of this workshop, we will cover where we are with the current beer flavor wheel and where we could go, with help from some classic research by Michael Lewis and our friends in the wine industry. We will also explore the use of references to expand our beer mouthfeel vocabulary.

*Sunday Highlights continued*

## Pearls of Wisdom

### All Brewer's Yeast Strains Are Similar and Do Not Significantly Contribute to Beer Characteristics

*Charles Bamforth, University of California and Anheuser-Busch Endowed Professor of Brewing Science, Davis, CA; Graham Stewart, GGStewart Associates, Cardiff, United Kingdom*
*Moderator: John Engel, MillerCoors, Milwaukee, WI*

How much do brewer's yeast strains matter when it comes to beer flavor and/or stability? A lot? Or, not at all, because other factors like raw materials and the brewing process drive flavor and stability? Surely you must have a position on this question! To find out what two of brewing's best have to say about it, don't miss this debate carried out as part of our popular Pearls of Wisdom series.

### Technical Subcommittee Meetings

Sunday, June 12 – Wednesday, June 15

Attend any of the ASBC Technical Subcommittee meetings during the ASBC Annual Meeting. Each meeting is specific to a technical subcommittee run from 2010 to 2011 and will provide an overview of the committee's results and recommendations. The meetings are open to all meeting attendees, and your feedback and participation in these meetings are essential to ensuring the quality of the methods being tested. In addition, there will be meetings for a number of standing subcommittees, including Methods of Analysis Reviews, Craft Brewers, and the Coordination of New and Alternate Methods subcommittees, where you will have the opportunity to make recommendations for future technical subcommittees. Check the daily schedule for subcommittees that will be meeting during the ASBC Annual Meeting.

### Welcome Reception

Make plans to attend the Welcome Reception to cap off the first full day of the ASBC Annual Meeting. The evening will be filled with great food and beer, as well as the company of friends and the opportunity to make new acquaintances. Single-day attendees and guests must purchase a ticket to attend this event.

## Monday, June 13

| | | |
|---|---|---|
| 7:00 – 8:00 a.m. | Speaker Breakfast: All Oral and Poster Presenters | Island |
| 8:00 a.m. – 3:00 p.m. | Registration | Registration 3 |
| 9:00 a.m. – 2:00 p.m. | Silent Auction Open | Palms Garden Foyer |
| **8:00 – 9:15 a.m.** | **Technical Session III – Health Topics in Brewing**<br>*Moderator: Aaron Porter, Sierra Nevada Brewing Co., Chico, CA*<br>8:00 a.m. O-9. M. Zarnkow. Purine input in the brewing process<br>8:25 a.m. O-10. L. Guerdrum. Levels of proteinaceous material in beer in relation to celiac problems<br>8:50 a.m. O-11. T. Henley. Effects of dark malts, dry hopping, and filtration on xanthohumol content and bioactivity of American India pale ales | Caloosa Ballroom |
| **9:20 – 10:00 a.m.** | **ASBC Guest Lecturer**<br>Changing Paradigms<br>Karl Siebert, Cornell University | Caloosa Ballroom |
| **10:00 a.m. – 12:00 p.m.** | **Exhibits and Hospitality** | Palms Ballroom |
| **10:00 a.m. – 12:00 p.m.** | **Poster Session**<br>(Authors Present: Even Numbers 11:00 – 11:30 a.m., Odd Numbers 11:30 a.m. – 12:00 p.m.) | Palms Ballroom |
| 10:00 – 11:00 a.m. | Technical Subcommittee Meetings<br>• Malt 13 DON/Malt 2B (Sortimat)<br>• Iso-Alpha Acids by HPLC/IBU by Segmented Flow Analysis/IBU in Wort by Spectrophotometer<br>• Sensory | <br>Hibiscus<br>Azalea<br><br>Periwinkle |
| 12:15 – 1:30 p.m. | Food and Beer Pairing Lunch | Everglades Ballroom |
| **1:45 – 4:30 p.m.** | **Technical Session IV – Yeast and Microbiology**<br>*Moderator: David Maradyn, Novozymes North America Inc., Franklinton, NC*<br>1:45 p.m. O-12. K. Smart. Optimizing fermentation: Yeast ethanol tolerance<br>2:10 p.m. O-13. H. Nguyen. The *MEL1* gene from the brewing yeast *Saccharomyces carlsbergensis* originates from *S. cerevisiae* and not from *S. uvarum* (or *S. bayanus*)<br>2:35 p.m. O-14. G. Zhou. The antibacterial effect of 10-HDA on *Pectinatus* spp. and wild yeasts in top-fermented wheat beer<br>3:00 p.m. Break<br>3:15 p.m. O-15. N. Bokulich. Lambic microbial community profiling using terminal restriction fragment length polymorphism | Caloosa Ballroom |

| | | |
|---|---|---|
| | 3:40 p.m. O-16. M. Kanauchi. Characteristics of β-glucosidase in brewery yeast<br>4:05 p.m. O-17. A. Panteloglou. PYF from the perspective of brewing yeast: Impacts on nutrient uptake and yeast fermentation characteristics. | |
| **4:30 – 6:00 p.m.** | **Workshop: The Wonderful World of Whiskies*** | Island |
| 4:30 – 11:00 p.m. | Hospitality | Gardens Ballroom |
| Evening | Open – Free Time | |

** Additional registration required*

## Monday Highlights

### ASBC Guest Lecturer

#### Changing Paradigms

*Karl J. Siebert, Cornell University, Geneva, NY*

*Karl J. Siebert*

People often attack problems by first looking in the literature for explanations and solutions. There are several risks with this approach: the current problem may have similar symptoms but a different cause from that described in the literature, the "conventional wisdom" may be incorrect, or a result is unbelievable at first sight and so may be dismissed as incorrect. With this shift in paradigms, it is essential that we take a new look at problems when they arise. He will highlight real-life scenarios where conventional wisdom has fallen short and discuss the successes of his career that have involved disproving commonly held beliefs.

### The Wonderful World of Whiskies*

*Steve Wright, Spiritech Solutions Inc., Ontario, Canada*
Workshop Fee: $25

Join Steve Wright, Canadian Whisky Ambassador, in a tasty technical tour of the wide wonderful world of whiskies. Attendees will be introduced to shining examples of whiskies from the great whisk(e)y producing countries or the world and will gain insights into the impact of regulations and manufacturing methods on the sensory features of Scotch, Bourbon, Irish, and Canadian whiskies. A structured tasting of select premium whiskies from around the globe will be featured, allowing attendees to experience the effects of grain selection, distillation design, maturation conditions, and blending techniques on the taste and aroma attributes of whiskies. Be prepared to learn details on the crafting of your favorite whisky style and see what sets it apart from other great whisky styles. A willingness to taste and enjoy is highly recommended!

### Food and Beer Pairing Lunch

An ASBC Annual Meeting favorite—be sure to take part in the Food and Beer Pairing Lunch! This year's theme is Flavors of the Caribbean. We start with the beer, and the chef takes it from there. The pairings will engage your palate and provide you with a better understanding of the nuances of pairing food and beer. This is a must-attend event!

## Tuesday, June 14

| | | |
|---|---|---|
| 7:30 a.m. – 3:30 p.m. | Registration | Registration 3 |
| **8:00 – 10:45 a.m.** | **Technical Session V – Analytical**<br>*Moderator: Kathy Kinton, MillerCoors, Elkton, VA*<br>8:00 a.m. O-18. M. Andersen. A new fluorometric method to determine sulfite- and thiol-containing compounds in beer<br>8:25 a.m. O-19. L. Lusk. Key olfactory cues for beer oxidation<br>8:50 a.m. O-20. L. Zhiping. Study on the analysis method for hop aroma components in beer and application for the evaluation of beer quality of hop aroma<br>9:15 a.m. O-21. J. De Clippeleer. Potential of selected ion flow tube mass spectrometry for real-time profiling of volatile malt aldehydes<br>9:40 a.m. Break<br>9:50 a.m. O-22. M. Holewa. Near-infrared spectroscopy in packaging control—Analysis of labeling adhesives<br>10:15 a.m. O-23. K. Tokita. A new method for analyzing characteristic flavor of beer using selectable 1D/2D GC-MS olfactometry | Caloosa Ballroom |
| 9:00 a.m. – 1:15 p.m. | Silent Auction Open | Palm Gardens Foyer |
| **10:45 – 11:30 a.m.** | **Emerging Issues** | Caloosa Ballroom |
| **11:30 a.m. – 1:30 p.m.** | **Exhibits and Hospitality**<br>(11:30 a.m. – 12:30 p.m. Lunch in Exhibit Hall) | Palms Ballroom |
| 11:30 a.m. – 1:30 p.m. | Poster Session<br>(Authors Present: Odd Numbers 12:30 – 1:00 p.m., Even Numbers 1:00 – 1:30 p.m.) | Palms Ballroom |

*Tuesday Schedule continued*

| | | |
|---|---|---|
| 11:30 a.m. – 12:30 p.m. | Technical Subcommittee Meetings | |
| | • Beta-Glucan by SFA/Malt 7 Alpha Amylase/FAN by SFA | Hibiscus |
| | • Craft Brewers | Azalea |
| | • International Hop Standards Committee | Island |
| 1:30 – 2:30 p.m. | Poster Take-Down | Palms Ballroom |
| 1:30 – 4:00 p.m. | Exhibit Take-Down | Palms Ballroom |
| **1:40 – 3:20 p.m.** | **Technical Session VI – Sensory and Stability**<br>*Moderator: Cecil Giarratano, Lakewood, CO*<br>1:40 p.m. O-24. T. Kunz. pH-dependent impact of metal ion complexes on haze formation and oxidative beer stability<br>2:05 p.m. O-25. B. Donaldson. Development of a hop aroma lexicon<br>2:30 p.m. O-26. A. Fritsch. A survey of sensory science in the beer industry<br>2:55 p.m. O-27. J. Steiner. Acceptance of off-flavors in beer by common consumers | Caloosa Ballroom |
| 3:20 – 3:30 p.m. | Break | Palm Gardens Foyer |
| **3:30 – 5:35 p.m.** | **Technical Session VII – Hops I**<br>Moderator: Tim Kostelecky, John I Haas Inc., Washington, D.C.<br>3:30 p.m. O-28. T. Inui. The detection of hop-derived aroma compounds in beer by using high-speed GC × GC TOF-MS and comparison of hop varieties in beer<br>3:55 p.m. O-29. C. Almaguer. A comparative study of the functionality of hop hard resins extracted from different hop varieties<br>4:20 p.m. O-30. H. Takemura. Influence of hop fraction on the quality of adjunct beer<br>4:45 p.m. O-31. S. Kappler. Increase in hop utilization by the use of easily applicable technologies and their influence on resulting beer quality<br>5:10 p.m. O-32. H. Imashuku. PIE: The effect on a commercial scale by boiling hops separately from wort | Caloosa Ballroom |
| **3:30 – 5:30 p.m.** | **Workshop: Breeding Success** | Island |
| 4:30 – 11:00 p.m. | Hospitality | Gardens Ballroom |
| Evening | Open – Free Time | |

## Tuesday Highlights

### Breeding Success

*Aaron Beattie, University of Saskatchewan, Saskatchewan, Canada; Richard Horsley, North Dakota State University, Fargo, ND*
*Moderator: Mary-Jane Maurice, Malteurop North America Inc., Milwaukee, WI*

This workshop will explore use of new biotechnological and other tools used by modern barley breeders in North America to unlock barley germplasm to find and use genes in new malting varieties responsible for critical components of malt and beer quality. The workshop will conclude with an open discussion on barley and malting.

### Emerging Issues Forum

*David Maradyn, Novozymes North America, Inc., Franklinton, NC; John Engel, MillerCoors, Milwaukee, WI; Cynthia Henson, USDA-ARS, Madison, WI; Bob Smith, SS Steiner Hops Extract Corp., Yakima, WA; Tom Shellhammer, Oregon State University, Corvallis, OR*

Join us for a session on questions and concerns related to current emerging issues pertinent to the brewing industry. A panel of experts from the malting, brewing, and hops industries, as well as academia, will take questions from the audience, giving attendees the chance to fully explore and understand the issues most important to their business.

## Wednesday, June 15

| | | |
|---|---|---|
| 7:30 a.m. – 12:00 p.m. | Registration Registration 3 | |
| 8:00 – 8:40 a.m. | Demonstration of the Online *ASBC Methods of Analysis* | Island |
| **8:40 – 10:20 a.m.** | **Technical Session VIII – Fermentation II**<br>*Moderator: Sylvie Van Zandycke, Lallemand Brewing, Milwaukee, WI*<br>8:40 a.m. O-33. G. Stewart. Wort FAN—Its characteristics and importance during fermentation<br>9:05 a.m. O-34. A. Tanigawa. Investigation of essential nutrients for yeast propagation and fermentation for low-malt– and no-malt–type beer beverages<br>9:30 a.m. O-35. S. Procopio. Interaction of nitrogen composition on aroma-active metabolites and flavor profiling<br>9:55 a.m. O-36. G. Zhou. An approach to brew beer vinegar with waste beer from spent yeast | Caloosa Ballroom |

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|---|---|---|
| 10:20 – 10:35 a.m. | Break | Palm Gardens Foyer |
| 10:35 – 11:35 a.m. | New and Alternate Methods of Analysis | Caloosa Ballroom |
| 11:45 a.m. – 1:15 p.m. | Publications Committee Meeting and Lunch | Hibiscus |
| 11:45 a.m. – 1:15 p.m. | Program Committee Meeting and Lunch | Azalea |
| **1:30 – 3:35 p.m.** | **Technical Session IX – Hops II** | Island |

*Moderator: Bob Foster, MillerCoors, Golden, CO*

1:30 p.m. O-37. P. Ting. Chelating beer soluble iron (BSI) in diatomaceous earth (DE) with hop acids

1:55 p.m. O-38. M. Ishimaru. Control of hop aroma in beer by hop boiling conditions

2:20 p.m. O-39. U. Wellhoener. Beer maturation: When is a beer mature from the dry hop perspective?

2:45 p.m. O-40. K. Takoi. Biotransformation of monoterpene alcohols by lager yeast and their contribution to the citrus flavor of beer

3:10 p.m. O-41. S. Kappler. First wort hopping and its influence on hop utilization rate and resulting beer quality

| | | |
|---|---|---|
| **1:30 – 3:35 p.m.** | **Technical Session X – Malting and Cereal Science II** | Caloosa Ballroom |

*Moderator: Scott Heisel, American Malting Barley Assn., Milwaukee, WI*

1:30 p.m. O-42. B. Schnitzenbaumer. Impact of various levels of unmalted oats on the quality and processability of mashes, worts, and beers

1:55 p.m. O-43. T. Ueda. Development of brewing technology using barley flake with improved productivity

2:20 p.m. O-44. A. Faltermaier. Changes in protein compositions during malting of common wheat (*Triticum aestivum* L.) and their influence on beer quality

2:45 p.m. O-45. D. Maradyn. Practical brewing with unmalted barley and Ondea® Pro: A craft brewer's perspective

3:10 p.m. O-46. M. Krahl. Functional beverages based on malted cereals and pseudocereals

| | | |
|---|---|---|
| 3:35 – 4:00 p.m. | Break | Palm Gardens Foyer |
| **4:00 – 5:15 p.m.** | **Closing Session: What's the Buzz?** | Caloosa Ballroom |
| 5:15 – 7:00 p.m. | Hospitality | Gardens Ballroom |
| 7:00 – 10:00 p.m. | Closing Reception | Everglades Ballroom |
| 9:00 – 11:00 p.m. | Hospitality | Gardens Ballroom |

## Wednesday Highlights

### Demonstration of the Online *ASBC Methods of Analysis*

*Cindy-Lou Bell, Anheuser-Busch InBev, St. Louis, MO; Chris Powell, University of Nottingham, United Kingdom*

Discover the 14th edition of the *ASBC Methods of Analysis* and learn how to improve the quality practices at your company through more effective use of this new online tool. Hear how the web-based *ASBC Methods of Analysis* offers increased integration across your company's network of technical staff with 24/7 access to the current methods and enhancements. Attendees will be taken on a tour of the methods to discover new and revised methods, updated sections, and integrated tools. Stops on the virtual tour will include a video demonstration, tutorials on statistics and EPR, and a sampling of more than 70 online calculators. Attendees will also get a look at the image library of brewery-related microorganisms, the built-in guide to beer inclusions, and the glossary of key brewing-related terms.

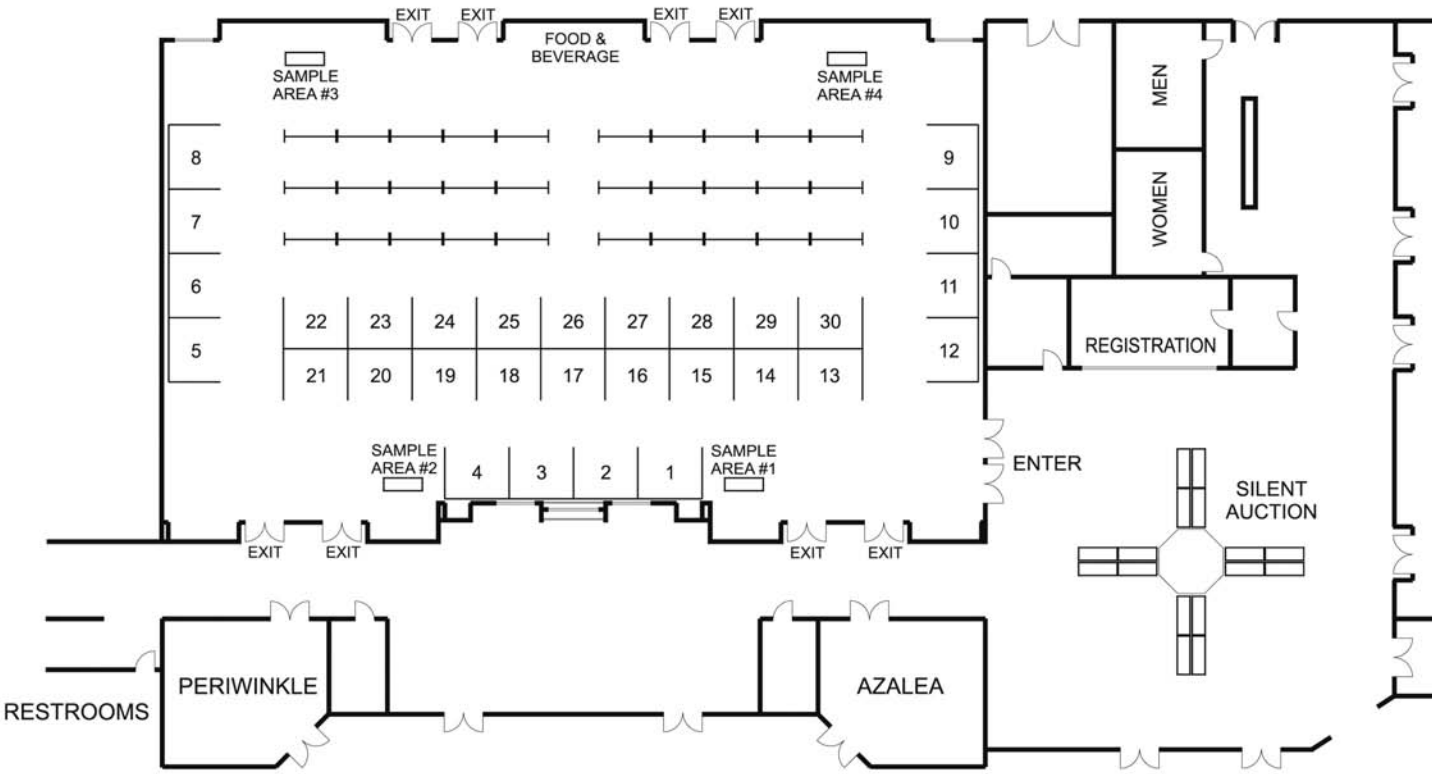
### Closing Session: What's the Buzz?

The Closing Session is an excellent capstone to the ASBC Annual Meeting. This interactive session will provide you with a recap of the entire meeting. The floor will then be opened for you to voice your thoughts about ASBC and discuss your experiences from the meeting. Make plans to join us for a great end-of-the-meeting synopsis.

### Closing Reception

Celebrate the conclusion of a great meeting at the Closing Reception. Unwind by enjoying hors d'oeuvres, a cold beverage, and relaxing with friends. Exhibitors and single-day attendees, as well as guests, must purchase a ticket to attend this event.

# Palms Ballroom Exhibit Floor Plan




## Numeric Exhibitor Listing

| Booth | Company |
|---|---|
| 1 | optek-Danulat, Inc. |
| 2 | LECO Corporation |
| 3 | Fizz Airgass |
| 4 | Hach Company |
| 5 | GEA Westfalia Separator |
| 6 | Munktell, Inc. |
| 7 | MicrOptix Technologies LLC |
| 8 | Nexcelom Bioscience |
| 9 | Gusmer Enterprises, Inc. |
| 10 | Parker domnick hunter |
| 11 | Siebel Institute and World Brewing Academy |
| 12 | Skalar |
| 13 | Ecolab |

| Booth | Company |
|---|---|
| 14 | DSM Food Specialties |
| 15 | White Labs, Inc. |
| 16 | Anton Paar USA |
| 17 | Cargill |
| 18 | Pall Corporation |
| 19 | Sigrist-Photometer AG/Peak Process Controls |
| 20 | PQ Corporation |
| 21 | Norit Haffmans |
| 22 | Astoria-Pacific |
| 24 | Sheldon Manufacturing Inc. |
| 26 | Bruker BioSpin Corporation |
| 29 | American Tartaric Products, Inc. |
| 30 | Profamo Inc. |

# Exhibitor Descriptions

** Indicates Corporate Member*

## American Tartaric Products, Inc.

1865 Palmer Ave., Larchmont, NY 10538; Telephone: +1.914.834.1881 or +1.815.357.1778, Fax: +1.815.357.6221, Web: www.americantartaric.com. ATP, one of the largest suppliers to the wine industry, is proud to present a range of products to the brewing industry. Our product range includes brewing process aids, antifoams, clarifiers, filtration aids, stabilizers, filter sheets, cartridges, filtration equipment, pasteurizers, packaging equipment, and analytical equipment. ATP represents well-respected and established companies such as Alfatek, Begerow, Birko, EP Minerals, ISP, Dextens, Padovan, Seital centrifuges, and others.

## Anton Paar USA*

10215 Timber Ridge Dr., Ashland, VA 23005; Telephone: +1.804.550.1051, Fax: +1.804.550.1057, Web: www.anton-paar.com. Ensuring the highest quality in production is the number one priority of beer manufacturers around the world. This can be achieved by combining laboratory testing and monitoring the beer directly in the production line. Visit our booth to learn about comprehensive solutions for beer analysis in the laboratory and for direct monitoring of beer in the main line offered by Anton Paar. All systems are designed and built with an emphasis on high precision and ease of use. For more information, visit the Anton Paar website: www.anton-paar.com.

## Astoria-Pacific International*

PO Box 930, Clackamas, OK 97015; Telephone: 1.800.536.3111, Fax: +1.503.655.7367, Web: www.astoria-pacific.com. Astoria Pacific was established in 1990 with the purpose of maximizing laboratory and production efficiency by offering automated analysis solutions. We are an American company that designs, produces, markets, and services analytical instrumentation and reagents to automate analytical chemistries. Our Astoria® and Astoria®2 flow analyzers and Astoria® Discrete analyzer rapidly and accurately measure alpha-amylase, beta-glucans, bitterness, diastatic power, diacetyl, free amino nitrogen, polyphenols, proteins (e.g., BSA), and more in beer and malt production processes.

## Bruker BioSpin Corporation*

EPR Division, 44 Manning Rd., Billerica, MA 01821; Telephone: +1.978.663.7406, Fax: +1.978.670.8851, Web: www.bruker-biospin.com. Bruker BioSpin Corporation manufactures EPR spectrometers for use in flavor-stability applications and contract analytical services. Bruker's EMX spectrometer is a high-throughput research system for both liquid and solid samples. The e-scan, bench-top spectrometer provides rapid, automated analysis for optimizing your beer's shelf life. The lag-time assay is used by several major breweries worldwide to determine and control the oxidative shelf life of lager beer. The EMX and e-scan spectrometers provide both the hardware and software to automate the lag-time assay.

## Cargill*

15407 McGinty Rd. W., Wayzata, MN 55391; Sweeteners – Telephone: +1.937.237.1236, Fax: +1.937.237.2529; Malt – Telephone: +1.742.742.4066, Fax: +1.952.742.5050; Flavor Systems – Telephone: 1.800.234.2539, Fax: +1.513.771.8748; Web: www.cargill.com. Let Cargill help you create great beverages for your customers. As the leading provider of quality ingredients, services, and innovative solutions to the worldwide brewing industry, Cargill's team can help you drive product innovation and optimize costs to support your growth goals for business success. Count on us to bring you the world's most complete line of brewing ingredients, including adjuncts, sorghum syrup, organic glucose syrup, pale and specialty malts, and flavors. To learn more about how Cargill can help you succeed, we invite you to call us or stop by our booth.

## DSM Food Specialties USA, Inc.*

45 Waterview Blvd., Parsippany, NJ 07054; Telephone: +1.973.257.8372, Fax: +1.973.257.3248, Web: www.dsm.com. Royal DSM N.V. is a global science-based company active in health, nutrition, and materials. A leading manufacturer and supplier of beer enzymes, DSM's advanced solutions help brewers worldwide save money, improve sustainability, boost efficiencies, and remain at the forefront of innovation. On-stand highlights include Brewers Clarex™, a revolutionary concept for beer stabilization that reduces energy costs and carbon footprints. Also on stand is Brewers Compass™. Containing every enzyme needed for efficient brewing, with 30–100% barley grist levels, Brewers Compass™ offers brewers the choice and flexibility to reduce costs and expand portfolios.

## Ecolab*

370 Wabasha St. N., St. Paul, MN 55102; Telephone: 1.800.392.3392, Fax: +1.651.293.2260, Web: www.ecolab.com. As the leading global provider of sanitation products and systems to the brewery industry, the Ecolab team will help implement and maintain practical solutions to help customers produce safer, high-quality products, continuously improve operational efficiency, and enhance environmental stewardship through best-in-class sustainability programs, including proprietary cleaners and sanitizers, conveyor lubrication programs that include dry lubrication, custom-engineered CIP systems and controls, water and energy management systems and services, effluent management, water reclamation, renewable energy production, and pest elimination services.

## Fizz Airgas*

5 Palm Row, Ste. E, St. Augustine, FL 32084; Telephone: 1.800.253.6610, Web: www.fizzdog.com and www.airgas.com. Fizz Airgas is a provider of gas and gas-related services for the brewing industry. We provide high-purity, beverage-grade $CO_2$ gas and liquid with purities up to 99.9999%, $H_2O$ below 250 ppb, THC below 10 ppb, and halocarbons below 1 ppb. We also provide nitrogen ($N_2$) and oxygen ($O_2$) PSA gas generation systems with purities from 99.8 to 99.999%, dew points to –40°C, and flow rates from 2 to 60,000 scfh. Additionally, we provide compressed air filters, sterile air filters, compressed air dryers, laboratory gas generators, and oil/water separators.

## GEA Westfalia Separator

100 Fairway Court, Northvale, NJ 07647; Telephone: +1.201.767.3900, Fax: +1.201.767.3901, Web: www.wsus.com. GEA Westfalia Separator is a leading manufacturer and distributor of high-quality separators and decanters for a wide variety of applications within the beverage industry. The company also offers PROFI®, a DE-free technology that combines centrifugal separation with membrane filtration for use in beer production. With full-service repair facilities on the East and West Coasts, GEA Westfalia Separator offers a complete maintenance, testing, engineering, training, repair, and spare parts capability. The company has been manufacturing centrifuges since 1893.

## Gusmer Enterprises*

1165 Globe Ave., Mountainside, NJ 07092-2903; Telephone: +1.715.258.5525, Fax: +1.715.258.8488, Web: www.gusmerbeer.com. For years, Gusmer has taken a revolutionary approach to serving the brewer's vision. It's why we have developed our extensive R&D and application support labs, offer the most advanced products, and provide a ready resource for problem-solving. Gusmer manufactured goods are skillfully developed, made in the United States, and created from the highest quality raw materials. We also distribute a variety of carefully selected, high-quality products from superior suppliers. Gusmer team members possess actual brewing experience and can match specific products to the needs of your brewery. Gusmer has what you need for your brewery.

## Hach Company*

PO Box 389, Loveland, CO 80539-0389; Telephone: 1.800.227.4224, Fax: +1.970.609.2932, Web: www.hach.com. Hach Company provides the most comprehensive portfolio of analytical solutions to ensure water and product quality. We design, manufacture, and distribute reagents, test kits, and instrumentation for testing water and product quality in a variety of brewery applications, including incoming water, fermentation, maturation, packaging, and effluent water treatment. Our products cover a wide variety of parameters, including dissolved oxygen, carbon dioxide, nitrogen, chlorine, turbidity, organics, and microbiology. They can be used in-line or in the lab, from spectrophotometry to complete package analysis. Convenient on-site service contracts available.

## LECO Corporation

3000 Lakeview Ave., St. Joseph, MI 49085; Telephone: 1.800.292.6141 (toll free) or +1.269.983.5531, Web: www.leco.com. For 75 years, industries around the world have trusted LECO to deliver technologically advanced products and solutions for analytical science. Today's technologies for separation science resolve complex samples and pioneer high-sample throughput using GC×GC, GC×GC-TOFMS, and GC-TOFMS. New high-resolution TOFMS systems offer an unprecedented combination of speed, resolution, mass accuracy, and dynamic range. A unique combination of easy-to-use software and advanced instrumentation provide an innovative solution for today's most demanding applications, including flavor/fragrance, environmental, and metabolomics.

## MicrOptix Technologies LLC

284 Main St., Ste. 400, Wilton, ME 04924; Telephone: +1.207.645.3600, Fax: +1.207.645.3633, Web: www.microptix.com. MicrOptix Technologies is focused on the development and commercialization of its patented, miniaturized, integrated sensing system into hand-held analyzing spectrophotometers. We are developing a new i-LAB® spectrophotometer specifically designed for breweries that measures many common beer properties. The i-LAB® hand-held analyzing spectrophotometer is a versatile and powerful instrument that allows users to record and compare spectral measurements in their work environment. This technology enables i-LAB® users to bring the instrument to the sample. For ease of conducting measurements, the i-LAB® features several measurement adaptor options for liquid and solid samples.

## Munktell, Inc.

7517 Precision Dr., Ste. 112 & 109, Raleigh, NC 27617; Telephone: +1.919.226.0752, Fax: +1.919.226.0758, Web: www.munktell.com. Munktell was founded in 1815 as the first company to manufacture analytical filter paper, and today we are one of the worldwide leaders in macro filtration. Headquartered in Falun, Sweden, we have a global presence, with subsidiaries in Germany and the United States. We offer pleated and flat filter papers, membranes, syringe filters, and other types of specialized filtration products for the brewery industry. Munktell is ISO 9000 certified and our products are manufactured according to MEBAK and EBC standards.

## Nexcelom Bioscience

360 Merrimack St., #9, Lawrence, MA 01843; Telephone: +1.978.327.5340, Fax: +1.978.327.5341, Web: www.nexcelom.com. Nexcelom is a leading manufacturer of automated cell counting and analysis instruments serving the brewing, biofuels, and biomedical industries. Their Cellometer instruments are used in the brewing industry to provide fast, accurate, and consistent concentrations and viabilities of yeast. The Cellometer system also automates sample tracking and data capture and can be easily integrated into existing work flows, increasing sample throughput and fermentation consistency. Please stop by our booth to learn more or visit www.nexcelom.com.

## Norit Haffmans*

1330 Anvil Dr., Rockford, IL 61115; Telephone: +1.815.639.0322, Web: www.haffmans.nl. Norit Haffmans is a leading supplier of total $CO_2$ and $O_2$ management systems, offering a wide range of quality control equipment, water deaeration systems, and blending and carbonation units. Norit Haffmans' quality control equipment measures $CO_2$, $O_2$, foam, and turbidity and monitors pasteurization. As your $O_2$ management measuring specialist, Norit Haffmans measures $O_2$ from wort production through filling, allowing you to track this important measuring point through the process. Norit Haffmans' $CO_2$ recovery technology, including brewery-type $CO_2$ recovery plants, liquid $CO_2$-stripping systems, and LiquiVap, the energy-efficient heat recovery system, allows you to recover $CO_2$ from fermentation sources.

## optek-Danulat, Inc.*

N118 W 18748 Brusen Dr., Germantown, WI 53022; Telephone: 1.888.837.4288, Fax: +1.262.437.3682, Web: www.optek.com. optek's process control instrumentation provides advanced and precise in-line analysis of product color, turbidity, haze, and constituent concentration for real-time results. Our in-line UV-VIS-NIR absorption-based photometers, insertion probes, and scattered-light turbidity meters monitor and control fermentation, filtration, separation, yeast pitching, wort color and clarity, DE and PVPP dosing, sanitizer concentrations, and more. In addition, optek recently introduced the Haze Control series of dual-angle lab and process turbidity meters for QA/QC, as well as NIST calibration solution standards. optek helps brewers achieve uninterrupted processing for the best possible product and reduced product loss, improved profitability, and greater efficiency.

## Pall Corporation*

25 Harbor Park Dr., Port Washington, NY 11050; Telephone: +1.516.484.3600 or 1.866.905.7255 (toll free), Fax: +1.516.801.9548, Web: www.pall.com/about.asp. For the food and beverage industries, Pall Corporation has developed filtration and advanced filtration systems that meet market needs for reliability and cost-effectiveness. Easy to install, and simple to use, the space-saving systems satisfy a wide variety of filtration requirements. Pall filters remove particulate contamination, ensure the absence of spoilage microorganisms, and provide high-quality air and gases. Membrane processes can additionally concentrate products without heat, purify and clarify, selectively remove components, and deal with process effluent.

## Parker domnick hunter*

4087 Walden Ave., Lancaster, NY 14086; Telephone: 1.888.587.9733, Fax: +1.704.921.1960, Web: www.parker.com/pdf. Parker domnick hunter is supported by innovative products, state-of-the-art technical facilities, and a specialized international team. Our capability is based on understanding the specific needs of your business and providing total system solutions. We offer $CO_2$ polishers for both plant-scale and retail dispense applications, nitrogen gas generators, process water chillers, compressed air treatment plus a full line of filtration products that assist beverage processor's in achieving the characteristics consumers demand—clear, sparkling products free of spoilage organisms and other contaminants.

## PQ Corporation*

PO Box 840, Valley Forge, PA 19482-0840; Telephone: +1.610.651.4200 or 1.800.944.7411 (toll free), Fax: +1.610.251.5249, Web: www.pqcorp.com. PQ's BRITESORB® silica gels meet the needs of brewers the world over and provide selective chillproofing performance with excellent filtration characteristics. The gels remove only the proteins that cause chill-haze, not those that stabilize foam. BRITESORB® beer stabilizers are manufactured in PQ's state-of-the-art production facilities to meet all regulatory requirements for food-grade silica and maintain consistent high quality and performance batch after batch, order after order. PQ BRITESORB® beer stabilizers are the clear choice for world-class beer.

## Profamo Inc.

7506 Albert Tillinghast Dr., Sarasota, FL 34240; Telephone: +1.941.379.8155, Fax: +1.941.379.8600, Web: www.profamo.com. Profamo Inc. is pleased to present at the ASBC Annual Meeting the revolutionary VitalSensors infrared in-line sensor, which measures, among other things, $CO_2$, alcohol, extract, and caustic and peracetic acid. This sensor is solid-state, requires no maintenance, and has no drift. It measures specifically the parameters mentioned above—no inferred measurements. We will also show the Dextens total package analyzer designed to measure in one package the true TPO, $CO_2$, alcohol and caustic (or peracetic) acid content. Also at the booth will be the Advanced Instrument's $CO_2$ purity analyzer; Rotech's keg-monitoring system; and the Pfeuffer sortimat and tannometer.

## Sheldon Manufacturing, Inc.*

300 N. 26th Ave., Cornelius, OR 97113; Telephone: +1.503.640.3000, Fax: +1.503.640.1366, Web: www.shellab.com. Sheldon Manufacturing is a leading manufacturer of high-quality and innovative constant-temperature equipment to the global market. Major product lines include incubators, humidity test chambers, ovens, water baths, and anaerobic chambers for the life science, pharmaceutical, biomedical, environmental, and industrial markets. Founded in 1970, Sheldon utilizes 40 years of manufacturing expertise to aggressively pursue new product opportunities that add value to our customers' portfolios. Sheldon markets a complete line of products under the SHEL LAB brand, which complements our OEM manufacturing capabilities. Visit us at www.shellab.com.

## Siebel Institute of Technology and World Brewing Academy*

1777 N. Clybourn Ave., Chicago, IL 60614-5519; Telephone: +1.847.284.2337, Fax: +1.312.255.1312, Web: www.siebelinstitute.com. The Siebel Institute of Technology and World Brewing Academy (a partnership between Doemens Academy and Siebel Institute) are proud to offer more brewing-related courses than any other school, including our web-based Concise Course in Brewing and our new web-based advanced-level WBA Associate Program. Our campus- and web-based programs cover the full range of brewing-related subjects, offering world-class training that ranges from the fundamentals of brewing to advanced-level programs designed and presented by the most talented instructors in brewing education. We also offer consulting, yeast management and production, lab services, and laboratory media for your QC/QA applications.

## Sigrist-Photometer AG/Peak Process Controls

17817 Leslie St., Ste. 45, Newmarket, ON Canada L3Y 8C6; Telephone: +1.905.830.6835, Fax: +1.905.830.6846, Web: www.photometer.com and www.peakprocess.com. Sigrist has been designing and manufacturing instrumentation for breweries for 65 years. In addition to its popular dual-angle in-line and lab turbidimeters, Sigrist now offers the new PhaseGuard, which can detect the beer–yeast or beer–water interface using color or turbidity. Sigrist is represented by Peak Process Controls Inc. in North America.

## Skalar, Inc.*

5012 Bristol Industrial Pkwy., Ste.107, Buford, GA 30518; Telephone: 1.800.782.4994, Fax: +1.770.416.6718, Web: www.skalar.com. Skalar, established in 1965, provides automated analytical instrumentation for the brewing and malting industries. This includes the Skalar SAN++ beer/malt analyzer that automates such tests as IBU (bitterness), total and free $SO_2$, alpha-amylase, beta-glucan, free amino nitrogen, diastatic power, polyphenols, soluble protein, and many others. Testing requires little or no sample preparation. Most methods are ASBC and EBC approved. In addition, Skalar manufactures the Primacs SN analyzer for total nitrogen in malt or wort. The Skalar analyzers meet the highest quality standards and have proven to be the most reliable and economical choice in today's modern routine laboratory.

## White Labs, Inc.*

9495 Candida St., San Diego, CA 92126; Telephone: 1.888.593.2785 or +1.303.530.0469, Fax: 1.888.693.1026, Web: www.whitelabs.com. White Labs, Inc. cultures pure liquid yeast for brewers, distillers, and wine makers. Our full-service laboratory provides beer and microbial analyses, analytical testing, and proprietary yeast banking and is the home of Siebel Analytical Lab Services. White Labs offers quality fermentation enzymes, Siebel lab media, laboratory supplies, quality control test kits, and brewing lab equipment. Our expert staff provides on-site or telephone laboratory consulting. White Labs partners with Frings America to provide high-performance yeast propagation systems in sizes from 14 L to 350 bbl. Our mission is to provide the highest quality product at a fair price with unparalleled service.

# Poster Presentations

P-47. Frank Verkoelen. "Always optical" modern oxygen management in breweries.
P-48. Sherman Chan. A novel homogeneous enzyme immunoassay for rapid on-site analysis of deoxynivalenol (DON) in grain.
P-49. Murthy Tata. A simple fermentation monitoring and control system.
P-50. Sylvie Deckers. Application of dynamic light scattering technique to detect the primary gushing potential from barley to finished beer.
P-51. Mark Zunkel. Beer flavor database.
P-52. Aaron Macleod. Brewing with low phytate barley malt—Increased mineral availability for improved fermentation.
P-53. Alnoor Pirani. Comparison of fluorescence methods for determining yeast viability using a novel automated image-based cell counting and viability system.
P-54. Ki Hyun Myoung. Degradation rate of marker genomic DNA reveals the inflow time of beer-contaminating insects.
P-55. Matthew Trass. Distilled spirit analysis using an aqueous-stable polyethylene glycol GC stationary phase.
P-56. Tomoko Ishibiki. Effect of serving temperature on flavor profile of beer.
P-57. Thomas Kunz. Fermentation with unfermentable sugars to improve the palate fullness and oxidative stability of beer.
P-58. Thomas Kunz. Glucose a reducing sugar? Optimzed method to ascertain the reduction potential of fermentable and unfermentable sugars in beverages and the brewing process.
P-59. Julien Billard. Important synergy role of glutathione (GSH) and catalase in the propagation of yeast *Saccharomyces cerevisiae* under $H_2O_2$ stress.
P-60. Patrick Jensen. Improved laboratory performance through the use of UHPLC technology for hop acid analysis.
P-61. Ronald Nixdorf. Improved management of technical beer tasters with a holistically managed solution.
P-62. David McMillan. Maintaining purchased $CO_2$ beverage gas purity levels to the published ISBT quality guidelines limits via multi-layer adsorption technology.
P-63. Josh Adler. Methods for increasing haze stability in wheat beer.
P-64. Ulaiwan Usansa. Optimization of wort production for brewing of rice malt using commercial enzymes and barley malt.
P-65. Rudolf Michel. Optimized fermentation and maturation with ECO-FERM™.
P-66. Thomas Kunz. Optimized hop mangement to improve the oxidative stability of wort and beer.
P-67. Brandon Mayes. Overcoming wastewater treatment plant limitations by ballasting the microbial floc.
P-68. Julien Billard. Overexpression of MAL and GSH genes with selected hybrid *S. cerevisaie* and induction with a specific maltose-amino acids medium.
P-69. Kara Taylor. Phenol quality control testing in yeast with gas chromatography.
P-70. Bettie Lodolo. Process improvements at the Ibhayi brewery, South Africa, from using a yeast monitor.
P-71. Yasuo Motoyama. Quality control method of beer-spoiler's detection media by using microbiological reference material: 2010 BCOJ collaborative study.
P-72. Matthew Trass. Rapid analysis of hop acids in beer using solid phase extraction and high-performance liquid chromatography.
P-73. Bryan Donaldson. Review of degassing methods for beer.
P-74. Gudrun Vogeser. Routine microbiology with PCR—What's new?
P-75. Kevin Connor. The effective use of propylene glycol-based secondary refrigerants.
P-76. Matthew Eckert. Method for the rapid determination of 4-methylimidazole in food and beverage products using LC/MS/MS.

# Abstracts

**O-1**

**Formation of styrene and the aroma compounds 4-vinyl guaiacol and 4-vinyl phenol by top-fermenting wheat beer yeast**

FRANK-JÜRGEN METHNER (1), Katrin Schwarz (1)
(1) Berlin Institute of Technology (TU Berlin), Berlin, Germany

Styrene, which is created by phenylalanine during mashing and wort boiling or by the enzymatic decarboxylation of cinnamic acid during fermentation, has been classified as "possibly carcinogenic to humans" by the IARC. The average concentrations of styrene in commercial wheat beers range between 3 and 24 µg/L and increase up to 65 µg/L during fermentation (temp. ADI 4 µg/kg BW). Previous analyses also showed that darker beer has a higher styrene concentration than pale beer. However, there was no linear correlation between the cinnamic acid and phenylalanine concentration in wort and the styrene concentration in finished beer. Concluding from this, there is evidence that the formation of styrene mainly depends on the applied mashing, wort boiling, fermentation and maturation process. First of all, the employed yeast strains and the temperatures during fermentation are important factors. This is confirmed by fermentations with different top-fermenting yeast strains, e.g. W68 with and without the addition of cinnamic acid. 4-vinyl guaiacol and 4-vinyl phenol, two of the main aroma compounds of wheat beer, are created by the enzymatic decarboxylation of ferulic and p-coumaric acid during fermentation. The level of these phenolcarboxylic acids and therefore the concentration of aroma compounds in beer depends on the used wheat fraction and the roast intensity. While styrene is formed at the beginning of the fermentation, the other 4-vinyl-derivates are not created in greater quantities until the cinnamic acid is completely converted. Styrene reaches its peak after 24 h while the concentrations of 4-vinyl guaiacol and 4-vinyl phenol accumulate during the whole fermentation process. Excluding the influence of other decarboxylases, the results may prove that cinnamic acid has a higher enzyme affinity than ferulic and p-coumaric acid.

*Frank-Jürgen Methner studied brewing science at Berlin Institute of Technology (TU Berlin) from 1975 to 1981. After finishing with a Dipl.-Ing. degree, Methner began working as an operating supervisor at the Schlösser Brauerei, Düsseldorf. From 1982 to 1986 he was a scientific assistant with teaching duties at the Research Institute for Brewing and Malting Technology of the VLB in Berlin. For 18 years, starting in 1987, Frank-Jürgen has held a leading position as a director at the Bitburger Brauerei, Bitburg, Germany, with responsibilities in fields such as technology and quality assurance. Beginning with the winter semester of 2004/2005 he took over the chair of brewing science at TU Berlin.*

**O-2**

**A comparison of small-scale fermentability assays to industrial-scale fermentations**

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Malt barley breeders and maltsters often strive to improve the quality of their product by selecting for and/or manipulating the fermentability of their malt. The fermentability of novel malt barley varieties is the most important characteristic for acceptance of the grain by industry. Small-scale assays are often used to assess the fermentability of malt; however, it is unclear how these trials correlate with industrial processes. This uncertainty may allow poor genetics to be propagated by malt barley breeders or promising varieties to be rejected by industry. There are several factors that likely contribute to discrepancies in fermentability such as pitching rate, mashing regime, fermentation temperature, barley modification, and batch size. This study aimed to isolate and examine the effects of fermenter size on brewing by undertaking small-scale (15 and 200 mL) assays in parallel to industrial fermentations. Using wort supplied by local breweries, miniature fermentations were conducted in parallel to their industrial counterparts. Samples were taken from each fermentation vessel at regular intervals throughout the fermentation. Turbidity was assessed spectrophotometrically at 600 nm and specific gravity was measured using a portable densitometer. It was found that fermentation size had an affect on the apparent degree of fermentation for larger breweries, but not for smaller operations. The discrepancy observed was consistent for each brewery. For example, a large difference of 1.1°P ± 0.2°P was observed between the final gravities of a 20-hL brewery and a 15-mL assay over three consecutive experiments. However, when the wort from an 8.5-hL microbrewery was tested using the small assay, no statistical differences in final gravity were found. During these trials, the turbidity trends were identical; however, the absorbance of the small-scale assay was consistently lower. It was hypothesized that the increased shear generated within the larger scale fermentors maintained the yeast in suspension longer, thereby affecting the final gravity. The shear generated through consumption of sugar and subsequent production of carbon dioxide was theoretically determined for each fermentor. The reduced shear generated within the shorter fermentors likely influenced the yeast floc distributions and subsequent final gravity. To properly make use of small-scale assays, a size correlation was proposed to rationalize the effect of fermentor size on fermentations. Work is currently ongoing to further quantify and control the variables that influence observed discrepancies between small-scale assays and industrial fermentations.

*Andrew J. MacIntosh was awarded a diploma of engineering from Saint Mary's University (Nova Scotia, Canada) and a B.Eng. degree in biological engineering from Dalhousie University (Nova Scotia). After working in industry for several years, he took the opportunity to complete an MAS degree in biological engineering and is now pursuing a doctorate degree in the applied field of food science. Andrew is currently completing the 5-year engineer-in-training apprenticeship to achieve the status of professional engineer. In addition to ASBC, Andrew is also a member of the American society of Biological Engineers and regularly serves on the council of the Dalhousie Engineering Graduate Society. When not conducting research, Andrew is an avid home brewer. His background has contributed to many successful experimental brews, in addition to the odd catastrophe.*

**O-3**

**Maltotriose fermentation by beer yeast induction of the maltotriose transporter by selected yeast strains and the maltose maltotriose medium during propagation**

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Maltose (60–70%), maltotriose (14–20%), and glucose (10–15%) are the most abundant fermentable sugars in wort. In case of incomplete fermentation, maltotriose can cause a range of detrimental qualitative problems in beer and ethanol loss. Furthermore, yeast which comes pre-grown on glucose biomass cannot fully adapt itself to wort composition during beer fermentation. The development and production of selected beer yeast for a fast and complete metabolization of these three main fermentable sugars in wort has been considered. The performance of fermentation was followed through the optimization of the culture medium, reproducing accurately the wort composition by monitoring yeast growth, ethanol synthesis, original gravity and attenuation, and sugar consumption during the fermentative process. Beer flavor was evaluated through the content of fusel alcohols, volatile esters, and aroma compounds. The expression of AGT1 (MAL11) – MTT1 (MAL31-like) is a limiting step in the fermentation of maltotriose in the beer yeast actually used. The selected strains expressing a maltotriose transporter

show a significant difference in kinetic fermentation and metabolization of sugars. The MTT1 transporter has a high affinity toward maltotriose. The presence of MTT1 in the selected strains and its induction by the composition of the medium during propagation leads to a higher efficiency in maltotriose consumption. The medium constitution for the biomass production of the selected yeast strains CBS 1513 (ex *Saccharomyces carlsbergensis*) and CBS 1503 (ex *S. monacensis*) "traditional medium" showed better gene expression in the maltose medium. The results obtained confirmed that the same strain produced on maltose medium gave more capacity to metabolize maltose and maltotriose.

*Mustapha Nedjma was the director of the Research and Development Department within AEB Group and was in charge of biotechnologies since 1997 in the facility based in Ile de France (near Paris). He received two postdoctoral positions specializing in microbiology, enzymology, and fermentation. He has published several papers, reviews, and patents for the beverage industry, especially in the beer, wine, and juice fields. His current research activities include beer fermentation and production of enzymes under solid-state fermentation.*

**O-4**

**Chemometric investigation of barley and malt data**

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Barley samples were pilot malted at the Canadian Malting Barley Technical Centre, where analyses of the barleys and malts were performed. The barley data contained 8 observations each for approx. 360 samples; 14 cultivars and 9 crop years were well represented. Principal components analysis (PCA) applied to this data found three significant PCs, indicating that the 8 measurements actually contained information on three fundamental properties. The first PC was heavily influenced by assortment and 1,000-kernel weight. The second PC was influenced positively by germination and negatively by moisture content. The third PC was mainly related to protein content. Pattern recognition procedures were partially successful in classifying barley samples by cultivar or crop year. When 14 measurements for 538 malt samples were analyzed with PCA, it appeared there were five fundamental properties. The first PC was heavily influenced negatively by friability and positively by β-glucans, viscosity, and fine/coarse difference; essentially, this represents modification. The second component was mainly influenced by α-amylase and diastatic power and the third by both fine and coarse extract. The fourth PC was influenced positively by soluble protein and wort color and negatively by wort pH. The fifth PC was heavily influenced by Kolbach index and free amino nitrogen. Relationships between the barley and malt samples were sought using partial least squares regression.

*Karl Siebert received a Ph.D. degree in biochemistry from Penn State in 1970. He then joined the Stroh Brewery Company in Detroit, MI, where he spent 18 years and held positions ranging from research associate to director of research. In 1990, Karl joined Cornell University as a professor of biochemistry in the Department of Food Science and Technology. He served five years as department chair and now has a predominantly research commitment. Karl is active as a consultant in beverage technology and chemometrics. He twice received MBAA Presidential Awards for papers he presented, and he and his colleague, Penny Lynn, received the ASBC Eric Kneen Memorial Award (for the best paper in the* ASBC Journal *in the prior year) three times. Karl was made an Honorary Professor of the Moscow (Russia) State Academy of Food Processing in 1996, and in 1999 he received the ASBC Award of Distinction. He is currently a member of the ASBC Journal Editorial Board and the ASBC Foundation Board. Karl's research interests involve foam and haze in beverages, perception of astringency and other flavors, the application of chemometric methods in food science, and assessment of microbiological risk.*

**O-5**

**Modifying the malting conditions of common wheat (*Triticum aestivum* L.) by using response surface methodology to ensure processability for brewing purposes**

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Wheat has a long tradition as a raw material for the production of malt and beer. Nevertheless, it has been studied to a much less extent than barley. Currently, wheat is used for the production of wheat beer, a beer style which still is increasing in sales. The two main countries producing this type of beer are Germany and Belgium. In increasing amounts, specialty brewers in the United States are creating American Wheat beers which are comparable to the German and Belgium style. In 2009, about 700 million metric tons of wheat were produced worldwide, but until now only a very low percentage is used for brewing purposes. Many wheat varieties are not suitable for brewing, since high protein content is not appropriate for the production of beer, since it leads to problems during downstream processing of beer such as lautering and filtration problems, foam stability, and deficient haze stability. Selected criteria have to be set for wheat as a raw material and its suitability for the production and processability of wheat-based fermented beverages. The used varieties as well as malting conditions have an important influence on the quality of malt and beer. Up till now, malting of wheat has received attention though to a very limited extent compared to barley. No strict specifications for wheat and wheat malt could be set by brewers, because characteristics of both greatly vary depending on variety and malting procedure. Due to this fact, an RSM-based design was made to analyze differences in proteolytic and enzymatic changes which take place during the malting process. The results were compared with established parameters and settings of barley for brewing. The influence of three malting parameters, vegetation time, degree of steeping, and germination temperature, to the quality of wheat malt was investigated. The different malts were compared to each other to ensure the processabillity for brewing purpose. Pilot-scale brews were done with some modified malts. Differences in sensorial and analytical attributes could be demonstrated. Thereby, optimized malting conditions for an improved beer quality are shown in this paper.

*Andrea Faltermaier studied food technology at the Technische Universität München (TUM), Weihenstephan, Germany. She performed her diploma thesis work at the Lehrstuhl für Brau- und Getränketechnologie, TUM-Weihenstephan. Since 2009 Andrea has been a Ph.D. student at the University College Cork (UCC), and she received the InBev-Baillet Latour Scholarship in Brewing and Malting. Her Ph.D. project, a cooperation between UCC and TUM, deals with studies on the application of wheat in brewing and functional beverages.*

**O-6**

**Effects of fungal contamination of barley malt on yeast in suspension during fermentation**

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Premature yeast flocculation (PYF) in brewing fermentations is a concern to both the malting and brewing industries. The exact causes of PYF are likely varied; however, it is hypothesized that exposure of barley grains to indigenous microflora has an effect upon the behavior of yeast cells during subsequent fermentations. In this study, the effect of microbial contamination on barley fermentation was investigated using small-scale assays. Two varieties of barley (CDC Bold and AC Metcalf)

were field inoculated with one of three common fungal infections: spot blotch (*C. sativus*), head blight (*F. graminearum*), and net blotch (*P. teres*). Each sample was malted, mashed, pitched, and fermented using a high-precision mill, automated mash bash, and temperature-controlled fermentation vessel (±0.1°C). Fermentations were performed in triplicate using a small-scale (15-mL) assay. During each fermentation, samples were taken at set intervals (1, 6, 22, 26, 30, 46, 50, 54, 70, 74, and 78 hr). Yeast turbidity was spectrophotometrically assessed at 600 nm while apparent extract was determined through density measurements of the wort. It was found that the final turbidity (linked to yeast in suspension) differed significantly ($P > 0.05$) between most control and infected samples. In the fermentation of most fungal-infected malts, the data show turbidity peaking sooner and declining more quickly than the control malt. It was also found that the degree of difference from the control correlated very well with established susceptibilities of the barley varieties to the introduced fungal species. In general, CDC Bold, which is reported to possess 'very poor' resistance to all three fungi, exhibited poor yeast in suspension behavior when infected. AC Metcalf, which is ranked higher than CDC Bold in resistance to these fungi, exhibited little or no PYF behavior. For example, CDC Bold, when exposed to *F. graminearum*, showed a peak in turbidity 12 hr earlier than the control and declined to less than half the turbidity by 78 hr when exposed to that fungus. Conversely, AC Metcalf, when exposed to *C. sativus*, displayed no significant ($P > 0.05$) change in turbidity versus its control. The observed changes to yeast in suspension are consistent with the phenomenon of premature yeast flocculation. Given that these fungal infections appeared to trigger PYF in laboratory studies, further examination is warranted.

*Emily Eck is a research technician at Dalhousie University in Halifax, NS, Canada. In 2010 she completed her B.S. degree in environmental science and economics at Dalhousie University and the University of King's College. Since 2009, she has been working in the Dalhousie brewing laboratory under the direction of Alex Speers. Her current research is focused on malt fermentability and small-scale fermentation assays.*

**O-7**

**Impact of the infection of *Fusarium culmorum* on the ultrastructure and mycotoxin content of malted barley**

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The contamination of barley with *Fusarium* species has been a long-standing problem for the malting and brewing industry, causing significant economical losses. In addition to this, mycotoxins produced by fungi are a major source of problems with respect to public health. The objective of this study was to evaluate the impact of *Fusarium* infection on barley malt quality. Special emphasis was placed on ultrastructural changes, on *F. culmorum* growth, as well as the formation of mycotoxins. Malting was carried using standard MEBAK parameters in a UCC pilot-scale unit. Two different batches were produced: one control (100% standard barley) and one contaminated mixture (20% *F. culmorum*-contaminated-barley + 80% standard barley). In total, eleven samples for analysis were collected along the malting process. Raw barley was disinfected by a series of $H_2O_2$ baths follow by UV light to be inoculated with an *F. culmorum* macroconidia suspension. The fungal growth behavior was evaluated by a set-up PCR and Fluorometric-based method. After extraction, *F. culmorum* was amplified by PCR using primers designed for specific genes involved in the trichothecene synthesis. The PCR product was then quantified photometrically by applying a fluorescence dye which specifically binds to double-stranded DNA. Kernels were analyzed for *Fusarium* commonly produced mycotoxins (deoxynivalenol, nivalenol, zearalenone, and zearalenol) by HPLC. Scanning electron microscope (SEM) and confocal laser scanning microscope (CLSM) were used to study the kernel's ultrastructure. Malt quality was assed by standard methods described by EBC and ASBC. The contaminated grains exhibit significant fungal growth during steeping, germination, and kilning. The final barley malt contained deoxynivalenol at 280 µg/kg. SEM pictures show fungi hyphae penetrating kernels and destroying the well-structured complexes of starch granules and protein matrix. Mycelia was able to penetrate healthy mature kernels from the testa layer, disrupting the aleurone layer, thus losing its permeability and evidencing extensive amylolysis and proteolysis degradation. Changes in a kernel's β-glucan and protein fractions were clearly seen by CLSM using a series of different dyes. *Fusarium* contamination also influenced overall malt quality.

*Pedro Oliveira studied food science and technology at the Technical University of Lisbon, Portugal, which included one year at University College Cork, Ireland. During his master's thesis studies, "Development of New Fermented Beverages Using Immobilized Yeast," he developed innovative fermentation processes and provided teaching and consulting. He then joined the Manufacturing Support Department of Nestle in Switzerland for six months to gain expertise in spray-dryer and fluidized-bed technology. Next, he joined the Les Mouquetaire Group in France for eight months to gain expertise in sensory analysis and market research. He has been a Ph.D. candidate in the School of Food and Nutritional Sciences, University College Cork (UCC), since 2010. His main research focus is the application of antifungal compounds from novel lactic acid bacteria strains isolated from the brewing environment and their application in malting and brewing. He is also in charge of UCC microbrewery facilities, and he is giving classes as a demonstrator in food analysis to students in the Food Science and Technology course.*

**O-8**

**Malting extremely small quantities of barley**

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Micromalting procedures for malt quality analysis typically use 50–500 g of barley, and can produce representative malts for evaluation of malting quality potential in barley breeding programs. Modifications to routine micromalting protocols in which small quantities of grain within inexpensive mesh containers are surrounded by a larger quantity of grain in standard-sized containers allow malts to be generated from 2 g of barley. Common malting quality parameters measured on these small-scale malts correlate well with those from standard malting and malt quality analysis, demonstrating their suitability for initial screening of malting quality. The smaller sample size enables multiplexing samples within a malting container, such that several different samples can be malted in the space formerly needed for a single sample, thereby increasing the potential malting throughput. The combination of this extremely small-scale malting procedure with previously described reduced-quantity mashing and malt analysis procedures can expand the capacity for preliminary screening of malt quality characteristics. This potentially benefits malting barley germplasm development programs by increasing sample throughput and reducing analysis turn-around time. In addition, the ability to generate and analyze representative malts on this very small scale may be useful in research studies where grain samples are limited, such as might occur in specially developed genetic populations. This ability to malt extremely small amounts of barley will also facilitate basic research studies examining the genetic and biochemical bases of malting quality.

*Mark Schmitt received his Ph.D. degree in plant physiology from the University of Wisconsin-Madison in 1983. He joined the Agricultural Research Service's Cereal Crops Research Unit in Madison in 2003 as a research chemist/lead scientist for a program that includes both basic and applied research on malting quality.*

**O-9**

**Purine input in the brewing process**

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The present work dealt with purine input through individual brewing raw materials during the production process. As a component of nucleic acid, purines are essential for metabolism. In certain circumstances, however, as a result of excessive intake through nourishment, they are able to benefit the development of metabolic diseases such as hyperuricemia and, consequently, gout. People suffering from hyperuricemia should avoid food with high purine content. In comparison with other aliments, beer has no particular high purine content. But the combination of alcohol and purines, which are present in beer, is critical for people suffering from hyperuricemia. A beer with a low purine content and perhaps reduced alcohol content could fill a market gap. For this work, samplings were conducted of the different brews during the complete production process in order to get a picture of the purine input in beer. High-performance liquid chromatography was applied to make the analyses of all samples. It could be shown that the main part of purines reaches the finished product through malt. In contrast, the purine input through hop is very low and, therefore, shall be disregarded. Depending on the performance type, the fermentation has a different influence on the purine content and can lead to its reduction as well as to its increase. Based on these results, congress mashes were made of malts from different types of cereals and pseudocereals. It could be shown that wort with reduced purine content can be produced with malts consistent with the Purity Law as well as with malts that are not in accordance with this law. An analyses of different beer types also showed that the purine content is mainly influenced by malt and fermentation. Beer types whose throw is very high, such as in the case of bock beer, showed higher purine contents than lower brewed beers, such as different pilsner and wheat beer types. At the same time, the extremely low purine content in the wheat beers allowed us to conclude that a warm fermentation clearly decreases the purine content. Brewing beers with reduced purine content could be possible by means of adequate raw materials and a correlative warm fermentation.

*Martin Zarnkow apprenticed as a brewer and maltster from 1989 to 1991 at a small brewery in Frankonia. Martin finished a diplom-ingenieur (FH) degree, with a brewing technology option, in 1996 at TU München, Weihenstephan, Germany. Martin worked as a brewmaster for one year in a medium-sized brewery in Germany. Since 1997 Martin has been the head of the research group for beverage technologies and head of the central laboratory at the Lehrstuhl für Brau-und Getränketechnologie (Institute for Beer and Beverage Technology) at TU München in Weihenstephan. In 2010, Martin finished his external Ph.D. research at the University College of Cork, Ireland, on the subject "Proso Millet (*Panicum miliaceum *L.) a Sustainable Raw Material for the Malting and Brewing Process."*

**O-10**

**Levels of proteinaceous material in beer in relation to celiac problems**

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About 1% of the Western population suffers from celiac disease, making it one of the largest food sensitivities in the world. celiac disease is an inherited immune-mediated enteropathy that damages the small intestine, thereby interfering with nutrient absorption upon consumption of gluten. Patients with celiac disease must abide by a strict gluten-free diet void of wheat, rye, barley, and possibly oats. Clinical sensitivity toward gluten differs considerably among patients but the current Codex Alimentarius standard for a food to be labeled as gluten-free is no more than 20 ppm gluten. As most beers are brewed from barley- or wheat-based grists, it has long been inferred that they are not suitable for people suffering from Celiac disease. However the veracity of this conclusion has been questioned, bearing in mind the considerable amount of protein modification and removal that occurs during malting and brewing. Review of the available methodology concluded that the most reliable procedure that ensures quantification of all the relevant proteinaceous material (including degradation products) is the so-called competitive R5 ELISA method. This method was used to assess the levels of gliadin in commercially available beers spanning the range of grist material. Gliadin levels ranged from <3 mg/L for gluten-free beers to 145.8 mg/L for filtered American pale wheat beers. With regards to the Codex Alimentarius standard, 10 of the 28 beers tested were within the guidelines. Many well-known brands in the United States have very low levels of detectable gliadin. The key brewing factors that impact gliadin levels are presented.

*Lindsay Guerdrum received a B.S. degree in biochemistry from the University of New Mexico in Albuquerque. She is currently in her second year as a food science and technology master's student at the University of California, Davis. During the summer of 2010 she worked as an intern for Anheuser-Busch InBev in Fairfield, CA.*

**O-11**

**Effects of dark malts, dry hopping, and filtration on xanthohumol content and bioactivity of American India pale ales**

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Xanthohumol (XN), a prenylated chalcone found in hops (*Humulus lupulus* L.), has been shown to possess a wide spectrum of beneficial properties, including antioxidant, anti-proliferative, pro-apoptotic, anti-inflammatory, antibacterial, antiviral, and antimalarial activities. Efforts have been made to increase the amount of XN in beers by modifying certain brewing ingredients and procedures. However, the effects of modifications such as addition of dark malts, dry hopping, and filtration on XN content and the biological activity of American India pale ales (IPAs) are not known. In this study, different brands of IPAs with and without addition of dark/roasted malts, dry hopping, and filtration and one German pilsner were analyzed for XN, isoxanthohumol, total phenolic content, and antioxidant capacity. Isolated beer compounds and selected whole beer matrixes were used to determine the synergistic effect of beer compounds on proliferation and apoptosis of HCT 116 p53 +/+ colon cancer cells. Significant differences ($P > 0.05$) in XN content among beers were observed. A heavily dry-hopped IPA made with increased amounts of dark malt contained higher amounts of XN compared to other IPAs. Furthermore, the use of dark malts was protective against the removal of XN and other phenolics after diatomaceous earth (DE) filtration, and dry hopping significantly increased XN content in beer. Beers with higher levels of XN suppressed cell proliferation and elevated apoptosis in colon cancer cells compared with isolated XN and/or IX,, indicating that the biological effect of XN can be bolstered in the presence of other beer compounds.

*Twila Henley is finishing her M.S. degree in food science and food safety at Colorado State University. She has worked with Fort Collins microbreweries to produce bioactive and gluten-free beers and has done research in gluten-free malting.*

**O-12**

**Optimizing fermentation: Yeast ethanol tolerance**

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While optimization and consistency of large-scale brewing fermentations from inoculation and dispersal of biomass to product recovery is of critical economic and industrial importance, process innovation requires an effective understanding of the biological constraints and

opportunities of the system. Efficient fermentation requires conditions appropriate for ensuring high productivity while maintaining yeast viability and fermentation performance. However, optimal conditions for the former can be sub-optimal for the latter, leading to inconsistent and even "stuck" fermentations. Although it is recognized that yeast is exposed to fluctuations in oxygen concentration, osmotic potential, pH, ethanol concentration, nutrient availability, and temperature, the impact of these stresses on yeast fermentation performance is still not well understood. This paper will focus on the stresses customarily associated with the use of increased gravity from the perspective of osmotic and ethanol tolerance. The paper will demonstrate that previous assumptions concerning the relative impact of certain stresses may not be correct. In particular, we will focus on whether certain stresses could even be beneficial to fermentation.

*Katherine Smart completed a B.S. (with honors) degree in biological sciences at Nottingham University in 1987 and was awarded the Rainbow Research Scholarship to complete a Ph.D. degree in brewing yeast and fermentation at Bass Brewers, Burton-on-Trent, England. She then moved to Cambridge University to take up an appointment as a research fellow in the Department of Plant Sciences, where she worked on bioactive surfaces, biofouling, and bacterial contamination of beverages in collaboration with the beverage packaging company Elopak. In 1992, Katherine became a lecturer in microbiology and fermentation at Oxford Brookes University. By 2000, she had been appointed to the Scottish Courage Reader in Brewing Science and became the youngest Fellow of the Institute and Guild of Brewing. In 2005 Katherine moved to the University of Nottingham, where she became the SABMiller Professor in Brewing Science. She was nominated as a Fellow of the Royal Society for the Arts, Manufacturing and Commerce in 2009 and a Fellow of the Society of Biology in 2010. She leads brewing science at the University of Nottingham, which offers a state-of-the-art e-learning M.S. degree in brewing science, and established brewing science research programs in barley genomics, malting, yeast genomics, fermentation, and flavor. She is currently holding some £8 million in research funding for brewing and bioethanol fermentations. Katherine has received several awards for her research, including the Institute of Brewing and Distilling Cambridge Prize (1999), the prestigious Royal Society Industrial Fellowship (2001–2003), an Enterprise Fellowship (2002), and the Save British Science Award at the Houses of Parliament in the UK (2003). Her core research interests are yeast cell biology, fermentation (beer fermentations, bioethanol fermentations), and stress responses in yeast.*

**O-13**

**The *MEL1* gene from the brewing yeast *Saccharomyces carlsbergensis* originates from *S. cerevisiae* and not from *S. uvarum* (or *S. bayanus*)**

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For yeast taxonomists, *Saccharomyces pastorianus* (name given by A. Vaughan-Martini to honor L. Pasteur), including *S. carlsbergensis*, is the species name of brewing lager yeasts. This species was regarded as a hybrid of *S. cerevisiae* and *S. bayanus* by DNA/DNA reassociation. *Saccharomyces bayanus* (Saccardo, 1895), was recognized as a true species while *S. uvarum* (Beijerinck, 1898) has been reclassified as a synonym of *S. bayanus.* However, *S. carlsbergensis* (Hansen) and *S. uvarum* (Beijerinck) have been thought to be conspecific. The persistence of confusing the names of the species was highlighted in prior literature or, more recently, in studies that do not rely on the reclassification proposed by Vaughan-Martini and Kurtzman in 1985 (Stewart and Russel, 1983; Hinchliffe and Vakeria, 1989). Researchers are thus faced with a situation in which three yeast species are tightly linked by their given names, resulting in a name being used for two species. In an attempt to clarify this situation, we established the karyotypes of *S. uvarum* strains and compared them with those of *S. carlsbergensis* and *S. monacensis*. Indeed, they exhibited two distinct groups of karyotypes. The main reason for the confusion of *S. carlsbergensis*/*uvarum* was that *S. carlsbergensis* and *S. uvarum* are both cryophilic, expressing the capacity to degrade melibiose by melibiase activity and encoding by the *MEL1* gene, which has been cloned and sequenced in *S. carlsbergensis*. To date, *MEL1* is thought to originate from *S. uvarum*. With the availability of the genome of *S. uvarum* strain CBS7001, we selected primers to amplify and sequence the *MEL1* gene from several *S. uvarum* strains, which resulted in the *SuMEL1* nucleotide sequence. This one shares only 78% identity with the *MEL1* gene from *S. carlsbergensis* as well as three *S. cerevisiae* Mel+ strains: ATCC42367, CBS2354, and UWOPS03-461.4. We thus concluded that *S. carlsbergensis* carried the *ScMEL1* gene and not the *SuMEL1*. Consequently, based on karyotype and *MEL1* sequence criteria, *S. carlsbergensis* is different from *S. uvarum.* In our previous studies, *S. bayanus* itself revealed to be a hybrid *S. cerevisiae* × *S. uvarum*; thus, we reinstated *S. uvarum* (Beijerinck) as a bona fide species. In the same study, we showed that *S. carlsbergensis* carries sequences mainly from *S. cerevisiae* and some sequences derived from *S. uvarum* with multiple neutral nucleotide polymorphism (MNNP) qualified by many authors as lager sequences. Conclusion: *S. pastorianus* is actually an *S. cerevisiae* × *S. uvarum* hybrid. *S. carlsbergensis* (*S. pastorianus*) is no longer a synonym of *S. uvarum*. The impact of melibiose was measured in experimental brewing with strains Mel+.

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**O-14**

**The antibacterial effect of 10-HDA on *Pectinatus* spp. and wild yeasts in top-fermented wheat beer**

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Previous studies in our laboratory have shown that 10-hydroxy-2-decenoic acid (10-HDA) displayed antimicrobial effect on $G^+$ beer-spoilage bacteria *Lactobacillus brevis* and *Pediococcus damnosus.* In the present report, we studied the inhibitory effect of 10-HDA on typical $G^+$ beer-spoilage bacteria *Pectinatus* spp. and wild yeasts. We also studied whether 10-HDA could be used in top-fermented wheat beer as a food additive and as an antimicrobial agent. 10-HDA was extracted from royal jelly with ethanol. The extraction efficiency was detected by high-pressure liquid chromatography (HPLC). The process of extraction was optimized using orthogonal experiments. The antimicrobial effect of 10-HDA on two strains of bacteria and three strains of yeasts was determined by inhibition zone experiments and flow cytometry assay. The antibacterial effect of iso-α-acid on these microorganisms was detected synchronously. The Oxford cup assay was used to determine the minimum inhibitory concentration (MIC) of 10-HDA by double dilution method. The results showed that 10-HDA could significantly inhibit *Candidamy coderma, Pectinatus cerevisiiphilus,* and *Pectinatus frisingensis*. No inhibition effect was found while treating top-fermenting yeast No. 303 and *Saccharomyces diastaticus* with 10-HDA. Similar antibacterial effects were obtained while using the flow cytometry test. In contrast, iso-α-acid only inhibited the growth of *Candidamy coderma* with MIC at a concentration of 62.5 mg/L. However, no inhibition effect was found when *Pectinatus* spp. was treated with iso-α-acid. 10-HDA was added to the top-fermented wheat beer with the bitterness 20.25 mg/L. The antimicrobial effect of 10-HDA in this kind of beer was determined by NBB culture medium test and microorganism

index analysis. The results showed that the 10-HDA displayed potent antibacterial effects while being used as a food additive in top-fermented wheat beer and the inhibitory effect of 10-HDA in top-fermented beer is not related to iso-α-acid. Our study provided evidence that 10-HDA could be developed as a novel antimicrobial agent in top-fermented wheat beer.

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**O-15**

**Lambic microbial community profiling using terminal restriction fragment length polymorphism**

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This work followed the microbial succession of yeast and bacteria in Belgian and American lambic-style, spontaneously fermented beers using terminal restriction fragment length polymorphism (TRFLP) as a tool for high-throughput community profiling, accompanied by culture-dependent tests. It was found that, generally, both American and Belgian beers followed the same progression, dominated by enterobacteriaceae and a range of oxidative yeasts in the first month of fermentation; these fermentations then ceded to *Saccharomyces* spp. and *Lactobacillus* spp. for the following year. After one year of fermentation, *Brettanomyces bruxellensis* was most often identified as the dominant population of yeast (occasionally accompanied by minor populations of *Candida* spp., *Pichia* spp., and other yeasts) and lactic acid bacteria (LAB) remained dominant, though various aerobic bacteria became more prevalent. This work demonstrates the utility of TRFLP as a technique for community analysis in beer and other fermented beverages.

*Nicholas Bokulich is a candidate for an M.S. degree in the Department of Viticulture and Enology at the University of California, Davis. He received his B.A. degree in microbiology and zymurgy at Hampshire College in 2008 before going to work for Anderson Valley Brewing Company in Boonville, CA.*

**O-16**

**Characteristics of β-glucosidase in brewery yeast**

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β-Glucan released from the endosperm cell walls of barley adversely affects brewing processes and beer. Therefore, the aim has long been to use endogenous or exogenous β-glucanases in the malthouse and brewhouse. However, it has been suggested that glucan degradation products may be prebiotic substances of benefit to the body. Furthermore, it has recently been proposed that certain hop aroma compounds are released in beer from non-flavorsome precursors through the action of β-glucosidase from yeast. Different yeast strains have different glycosidic enzymes and cause individual cleavage of glycosides during fermentation. This report describes a comparison of the characteristics of β-glucosidase from an ale strain and a lager strain. The enzymes have been partially purified and assayed using various substrates. In both strains. the activity is maximal after 7 days at 15°C, the level thereafter decreasing. The enzyme from the ale yeast was more heat tolerant and showed different inhibitor sensitivity to that from lager yeast. This presentation will report a range of characteristics for both enzymes.

*Makoto Kanauchi graduated from the Tokyo University of Agriculture, Tokyo, Japan, in 1996 and received a Ph.D. degree in bio-regulation control from that university in 1999. He worked in Professor Charles Bamforth's laboratory in the Department of Food Science and Technology, University of California at Davis, CA, from 1999 to 2003. Subsequently, he was employed at the Institute of Food Science in Fuji Oil Co. Ltd., Moriya, Ibaraki, Japan, as a researcher from 2003 to 2005. Since April 2005, he has been at the Department of Food Management, Miyagi University. He has also been a lecturer on enzymology and alcoholic beverages (mainly spirits and wine) at the Tokyo University of Agriculture since 2005.*

**O-17**

**PYF from the perspective of brewing yeast: Impacts on nutrient uptake and yeast fermentation characteristics**

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Premature yeast flocculation (PYF) is a sporadic problem encountered during industrial brewing fermentations. Factors, thought to arise from fungal infection of barley and malt, cause yeast to flocculate prematurely and/or heavily before the depletion of available nutrients in the wort. This results in poorly attenuated worts, with higher residual extract and lower ABV, flavor abnormalities, disruption of process cycle times and potential issues with the re-use of the yeast in subsequent fermentations. Whilst previous studies have focused principally on characterizing the PYF factor(s), or on the role of fungi and/or the malting process in their generation, current research in our group aims to characterize the impacts of PYF factors on metabolizing yeast. The aim is to improve the understanding of why some breweries' yeast strains are more susceptible to this condition than are others. An optimized PYF test based upon a 200-mL working volume was developed for the purposes of accurately differentiating PYF activity within this project (rather than as a generic screen for use by industry). Using this test and commercial PYF+ve and PYF–ve malts, it was shown that lager yeast strains differ in sensitivity toward the factor(s) in wort and that one particular strain showed no sensitivity in terms of suspended cell counts through fermentation. Yeast performance during PYF+ve and PYF–ve fermentations was compared for SMA yeast (a highly PYF-sensitive strain) using stirred miniature fermentation vessels (100 mL). In PYF+ve fermentations the peak budding index was found to be delayed (relative to PYF–ve wort), indicating changes in yeast cell-cycle progression. Furthermore there were delays in nutrient uptake in the first 12–24 hr of fermentation; specifically the uptake of free amino nitrogen (FAN), maltose, and maltotriose. Significantly lower amounts of alcohol were formed in the PYF+ve fermentations after 5–7 days.

*Apostolos Panteloglou received his B.S. degree in food technology from the Alexander Technological Educational Institute of Thessaloniki in Greece (2006). After a six-month placement in the technical team of the Brewing Research International (Surrey, UK) he completed an M.S. degree in food technology and quality assurance at the University of Reading (Berkshire, UK). Currently he is a Ph.D. research student at the University of Nottingham under the supervision of David Cook and Katherine Smart, investigating the occurrence of premature yeast flocculation in the brewing and malting industries.*

**O-18**

**A new fluorometric method to determine sulfite- and thiol-containing compounds in beer**

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Sulfite is an important antioxidant in beer, which has an important effect on oxidative stability. A method for sulfite determination in beer was developed based on formation of adducts with the maleimide-derived probe ThioGlo® 1 followed by high-performance liquid chromatography (HPLC) separation and fluorescence detection. Two peaks corresponding to sulfite derivatives were observed. HPLC with mass spectrometric detection showed that the two derivatives had identical mass spectra and confirmed that they were derived from sulfite. The quantification of sulfite in beer was affected by matrix effects, which made it necessary to use a matrix-matched calibration curve. ThioGlo® also forms adducts with thiols and a peak assigned to co-eluting thiol adducts was also seen in the HPLC chromatograms. The level of thiols in the beers were quantified as glutathione equivalents. The role of sulfite and thiols as antioxidants in beer was tested by addition of the reactive oxygen species hydrogen peroxide. The levels of sulfite and thiols decreased in parallel upon addition of increasing amounts of hydrogen peroxide. The decreases in concentrations were not proportional to the amount of hydrogen peroxide added. Extensive addition of hydrogen peroxide did not remove all the thiols, whereas sulfite was completely consumed. The experiment suggests that some thiols in beer may also protect against oxidation, and that synergistic effects together with sulfite may be important for the shelf life of beer.

*Mogens L. Andersen is an associate professor. He graduated from the Department of Chemistry at the University of Copenhagen in 1990, where he also obtained his Ph.D. degree in 1993 based on studies of mechanisms of organic electrochemical reactions. In 1996 he began working as an assistant professor in the Food Chemistry Group, Department of Food Science, University of Copenhagen, where he now is an associate professor. His research focuses on using electron spin resonance spectroscopy for studies of oxidative reactions in foods. This has included mechanistic studies of radical reactions in beer, meat, oils/lipids, and other foods. The work has also included mechanistic studies of antioxidants in foods, as well as development of methods for early prediction of oxidative stability. He has published 66 peer-reviewed scientific papers.*

**O-19**

**Key olfactory cues for beer oxidation**

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Numerous compounds that are subject to concentration changes have been suggested as markers of beer flavor instability. The subset of these compounds with a flavor impact is much smaller and includes compounds such as trans-2-nonenal (cardboard aroma) and methional (potato aroma). In the current work, GC×GC-olfactometry-MS was used to identify significant changes in aroma compound levels as beer aged. The key was to search for the significant changes in aroma, not necessarily the most intense aromas. A further challenge was confirming the chemical identity of low levels of flavor-active compounds buried in a chromatogram under much higher concentrations of compounds without flavor impact. The challenge was met through knowledge of the aroma, analysis of standard compounds (when available), and statistical PCA mapping of MS ions from narrow GC time windows. Compound identity was further confirmed using GC×GC-time-of-flight-MS. The beers used for this work did not develop typical cardboard aroma, and trans-2-nonenal was not one of the compounds identified. The compounds that significantly increased or decreased in aroma during 12 weeks of forced aging at 30°C were methyl mercaptan, methional, dimethyltrisulfide, phenylacetaldehyde, 1,1,6-trimethyl-1,2,3,4-tetrahydronapthalene (TMTN), citronellyl acetate, and δ-cadinene. TMTN is a flavor-active norisoprenoid oxidation product of carotenoids. This is an example of the oxidation product of an antioxidant contributing to oxidation character. δ-Cadinene is a minor sesquiterpene in hop oil. During beer fermentation, yeast biotransformation of hop-derived monoterpene alcohols leads to β-citronellol, which would provide a source for esterification to citronellyl acetate. Other researchers previously showed that methyl mercaptan, methional, dimethyltrisulfide, and phenylacetaldehyde contribute to beer oxidation aroma. The validity of the importance of this group of compounds as key olfactory cues for beer oxidation was demonstrated by the excellent multivariate analysis correlation ($R^2 = 0.99$) between the sensory panel scores (for oxidation increases over 12 weeks) and the flavor stability compound level changes (MS-selected ion monitoring values).

*Lance Lusk is an internationally recognized expert in beer flavor stability and foam properties. He is also an experienced brewery process troubleshooter and product and process improvement innovator. He has extensive knowledge of beer flavor gained through gas chromatography–mass spectroscopy–olfactometry analysis, as well as extensive experience with electron spin/paramagnetic resonance spectroscopy for beer free-radical analysis. He held various positions at Miller Brewing Company (now MillerCoors) for more than 29 years until his retirement. He is now a brewing consultant. Lance is a member of six professional societies, including ASBC and MBAA. Lance is the recipient of seven U.S. patents, the 1996 ASBC Eric Kneen Award, and the 2010 ASBC Honorary Life Membership Award. He has presented his work at ASBC and EBC meetings and the Jean de Clerck Chair. Lance's former interns include brewing professionals on three continents, a medical doctor, and the director of consumer insights at a major producer of flavors and fragrances.*

**O-20**

**Study on the analysis method for hop aroma components in beer and application for the evaluation of beer quality of hop aroma**

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A method for the analysis of hop aroma components in beer by headspace solid-phase microextraction with GC-MS was developed. Eight hop aroma components such as linalool from which 40 domestic and international samples were collected were precisely measured. Multivariate analysis was applied to analyze hop aroma, and 3 factors were extracted from principal component analysis, classifying hop aroma components into 3 categories. Correlation analysis shows that linalool, α-terpineol, and geraniol were significantly correlated with geranyl acetate and citronellyl acetate. Discriminant analysis showed that linalool, α-terpineol, geraniol, geranyl acetate, and citronellyl acetate of different origins varied greatly. The trial went in-depth to the influence of different hopping methods to beer hop aroma. Eight kinds of hop aroma components were not detected in unhopped beer. The content of hop aroma components was impacted significantly by adding different varieties of hops for the last addition. When boiling time was prolonged, the content of beer hop aroma components such as linalool decreased remarkably. When the addition quantity was constant, hopping in whirlpool instead of wort kettle could distinctively increase hop aroma components content.

*Lin Zhiping graduated from the School of Bioengineering of Jiangnan University, Wuxi, China, in 2003 with a master's degree in fermentation engineering. In 1994, Lin started his career with Beijing Yanjing Brewery Group Corporation, China. In 2003 he joined the Yanjing National-Standard Research Center, engaging in brewing technology research and development. He currently is deputy chief engineer of the Yanjing Group and supervisor of the China National Research Institute of Food and Fermentation Industries (CNRIFFI), as well as the supervisor of*

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**O-21**

**Potential of selected ion flow tube mass spectrometry for real-time profiling of volatile malt aldehydes**

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Flavor stability remains one of the main quality criteria for beer, and the urgency to control it is endorsed by the global beer market and its allied need for longer storage times for exported beer. Formation and release of volatile aldehydes is recognized as one of the main causes of beer flavor deterioration upon storage. Most of these compounds pre-exist abundantly in malt, and may vary significantly between different malt types. As such, the staling potential of finished beer is largely determined by the type of malt used in the brewing process. Consequently, knowledge of malt aldehyde content is indispensable for brewers in view of quality control, selection of the appropriate malt variety, and objective assessment of the flavor stability of processed beer. The potential of selected ion flow tube mass spectrometry (SIFT-MS) to differentiate malted barley cultivars on the basis of their headspace profiles has been investigated in this study. Prime focus is on the analysis of aldehydes and particularly as compared to the headspace solid-phase microextraction (SPME) gas chromatography-MS method currently used. The investigated aldehyde markers can be classified into Strecker degradation aldehydes (2-methylpropanal, 2- and 3-methylbutanal, methional, benzaldehyde, and phenylacetaldehyde), aldehydes formed during Maillard reactions (furfural). and lipid oxidation aldehydes (hexanal and trans-2-nonenal). SIFT-MS is an analytical technique that is based upon soft chemical ionization taking place in a flow tube reactor. A commercial SIFT-MS instrument (Voice200, Syft Technologies, Christchurch, New Zealand) was equipped with a direct inlet and a heated external interface, which provided direct entry of volatiles into the flow tube. Volatile emissions from ungrounded malt grains were sampled with a micro-chamber/thermal extractor (μ-CTE; Markes International, Llantrisant, UK). Dynamic headspace with the μ-CTE uses a substantially higher amount of material (25 g). As a result, higher absolute responses are easily obtained without the need to increase extraction temperature and without inducing stress-related emissions. By dynamic headspace SIFT-MS, the target volatiles were readily identified in the different malt headspaces. The technique exhibited an increase in specificity and speed compared with the headspace SPME GC-MS procedure. The unique feature of SIFT-MS to analyze malt sample headspaces rapidly and directly without the need for sample preparation, derivatization, or chromatographic preseparation is demonstrated. Principal component analysis (PCA) was successfully applied to discriminate between malt samples on the basis of the selected aldehydes in their volatile pattern. Furthermore, PCA displayed good reproducibility of the SIFT analyses and showed the high potential of SIFT-MS for fast classification of the different malt samples investigated. Knowledge of these variations in headspace profiles among various malted barley types, varieties, and harvest years is of great interest to the brewing industry.

*Jessika De Clippeleer obtained her M.S. degree in food technology, specialization food chemistry, from Wageningen University, The Netherlands, in 2003, after receiving an M.S. degree in industrial engineering in biochemistry at KaHo St.-Lieven, Gent, Belgium, in 2000, and studying at Escola Superior de Biotecnologia, Universidade Católica Portuguesa, Porto, Portugal, as an Erasmus student. She began employment with KaHo St.-Lieven in 2003 as a food chemist in the meat laboratory of the Biochemistry Department. In 2004 she joined the analytical laboratory of the Enzyme, Fermentation and Brewing Technology Research Group of KaHo St.-Lieven, where she started a Ph.D. study on beer flavor stability and hopping technology in 2005. In addition to her Ph.D. research activities, she is involved in several research projects and lectures on biochemistry and food safety. Her research experience is in the field of food chemistry, beer flavor stability, hop chemistry, and malting. Her expertise is in principles, technology, and applications of analytical chromatographic and mass spectrometric techniques.*

**O-22**

**Near-infrared spectroscopy in packaging control—Analysis of labeling adhesives**

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Breweries put a lot of effort on the quality control of raw materials and the product itself at the different process steps. On the other hand, hardly any testing is carried out at filling plants regarding the packaging means. This is common practice due to extensive testing equipment necessary for each single packaging material and property. In the presented research work, the possibilities of near-infrared spectroscopy in determining chemical and/or physical features of a large variety of packaging materials of the beverage industry are investigated. The study is carried out with a Fourier transformation spectrometer covering the whole near-infrared spectrum from 780 to 2,500 nm at a resolution of 4 $cm^{-1}$. Transmission measuring of liquid samples in glass vials as well as reflection measuring of solids is applicable. Using intricate multivariate calibration procedures, methods are developed for the analysis of labeling glue (contents of casein, urea, total nitrogen, starch, and solids as well as viscosity), bottle crates made of HDPE (UV-resistance), PET-bottles (content of additives like polyamide or oxygen scavengers and detection of coatings), and closures (material and additive identification). Two important components of labeling glue, urea and casein, both contain amine groups. In order to tell these nitrogen sources apart, 50 model solutions were produced containing different amounts of casein or urea only. Quantitative calibration led to good results and revealed the decisive spectral regions. In the next step, 30 model solutions containing casein and urea in varying concentrations and ratios were produced and calibrated successfully. To take another matrix effect of labeling adhesives into account, 15 more model solutions were produced with starch added. With these mixtures, methods for all three components could be developed that hit the actual concentration better than ±1%. Similar results were obtained in calibrations for total nitrogen, starch, and solids in 25 professional labeling glues when compared to the values of the reference analyzes. A proper method for the determination of the viscosity of these adhesives could not be established, though. Further studies on the other packaging means mentioned above are still in progress.

*Michael Holewa was born in 1971 and apprenticed to become a brewer and maltster from 1990 to 1992 at the Holsten Brewery in Hamburg, Germany. Subsequently he was employed there until he started his studies in brewing technology in 1993 at the Technical University of Berlin. After graduating in 2001, he went to the Binding Brewery in Frankfurt, Germany, for one year, working on analytics in the laboratory. In 2002 he changed to the Kölner Verbund Breweries in Cologne, Germany, doing quality assurance and project management. This engagement was followed by a job at the Pfungstädter Brewery in Pfungstadt, Germany, from 2005 to 2008, where he was responsible for quality management and process optimization. Since 2009 he has benn employed at the Research Institute for Engineering and Packaging of VLB Berlin, where he is currently doing research, consulting, and teaching.*

**O-23**

**A new method for analyzing characteristic flavor of beer using selectable 1D/2D GC-MS olfactometry**

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Flavor is an important factor for characterizing various types of beer. Recently, GC-MS-olfactometry (GC-MS-O) has been used for analyzing beer flavor. GC-MS-O allows not only evaluation of the flavor compounds, but also identification with mass spectral information. However, the sensitivity and resolution of this method are not sufficient to identify trace ingredients in beer. Moreover, GC-MS-O requires much effort to analyze trace ingredients, so that it is difficult to conduct a detailed analysis of whole flavor of beer. In this study, we introduced selectable 1D/2D GC-MS-O. Selectable 1D/2D GC-MS-O has high sensitivity and resolution, so that it could identify flavor compounds that are not separable by GC-MS-O. Additionally, to analyze the characteristic flavor of beer in detail, we decided to focus on target flavors that were applied to selectable 1D/2D GC-MS-O. We analyzed fruity and floral flavors in fruity-flavored beer, and identified them as esters, alcohols, terpenes, lactones, or phenols. Finally, we measured the content of these compounds, added them to the control beer, and made a sensory test. As a result, we could partly reconstitute the fruitiness of beer. This suggests that our method is useful for analyzing the characteristic flavor of beer.

*Keita Tokita received an M.S. degree from the Department of Integrated Biosciences, Tokyo University. He began employment with Sapporo Breweries, Ltd. in 2009 as an analytical chemist in the Frontier Laboratories of Value Creation.*

**O-24**

**pH-dependent impact of metal ion complexes on haze formation and oxidative beer stability**

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Our recent studies prove that the chill haze formation in stabilized beers is correlated to oxidative processes and generated reaction products of the Fenton-/Haber-Weiss reaction system after the consumption of the endogenous antioxidant potential (EAP). Our investigations clearly show that after the achievement of the EAP-zero value the reaction products of the Fenton-/Haber-Weiss system, such as $Fe^{3+}$, $Cu^{+}$, and $OH^{\bullet -}$ radicals, start interacting and generating metal ion complexes with oxidized, haze-active polyphenol-protein-complexes. These complexes are significant for the visible chill haze formation and the formation depends on the temperature because of the low bonding forces. Experiments which have been carried out under addition of metal ions with specific oxidation steps such as $Fe^{3+}$, $Fe^{2+}$, and others to beer within different pH ranges clearly show an increase in haze, caused by these complexes. When facing different pH areas, the highest haze formation was observed to be around the pH value of 3.5. It seems that based on the stronger bonding forces of specific metal ions in beer at a lower pH value a higher haze formation can be observed. This phenomenon can be explained by more bonding sites which are stabilizing the generated chill haze. However, the EAP consumption proceeds more slowly, because there is a lower concentration of iron ions available for the acceleration of oxidative processes and the radical generation by the Fenton-/Haber-Weiss reaction system. This results in a higher oxidative stability but later and stronger chill haze formation. Contradictory experiments at higher pH areas resulted in an earlier but lower haze formation due to the weaker bonding power in the metal complexes with haze-active polyphenol-protein complexes and in a significantly faster consumption of the EAP. Furthermore, experiments with and without oxygen addition allow the conclusion that the oxygen content is the most important factor for the formation of oxidized polyphenol-protein complexes and their further complexation with specific metal ions. In both cases (with and without oxygen addition), the metal ions are responsible for a higher haze generation by metal ion protein-polyphenol complexes. In separated chill haze from beer, an agglomeration of stabilized organic radicals also could be detected by EPR-spectroscopy. During the progress of beer aging, the oxidized polyphenol-protein-metal ion complexes, including the stable organic radicals, can react in radical reactions and form covalent bonds, one way for converting chill haze to permanent haze. Additional filtration trials with kieselguhr, CMF, and other filter aids show a clear influence of different metal ion insertion on the haze formation and oxidative beer stability. It has been shown that this research work can give useful further knowledge about avoiding the undesired haze formation in beer and other beverages.

*After qualifying as a certified technician in preservation engineering (1991–1993), Thomas Kunz completed his basic studies in chemistry at the University of Applied Sciences, Isny (1994–1995), and his basic studies in food chemistry at Wuppertal University (1995–1998), before starting to study food technology at the University of Applied Sciences, Trier (1998–2002). After graduating, he worked as a chartered engineer in the area of ESR spectroscopy at the Institute of Biophysics at Saarland University (2002–2004). Since 2005, he has been employed as a Ph.D. student at the Research Institute of Brewing Sciences, Berlin Institute of Technology (Technische Universität Berlin). His main research focus lies in analyzing radical reaction mechanisms in beer and other beverages using ESR spectroscopy.*

**O-25**

**Development of a hop aroma lexicon**

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Hops, while making a relatively modest contribution to the cost of producing beer, provide a disproportionate amount of flavor and aroma. Despite this, there has been very little research attempting to quantify the different aromas afforded to beer from hops. Development of a comprehensive lexicon of hop aroma will allow for more guided use of hops for brewers and allow for the consumer to be given more detail when selecting a product. To this end, 13 commercial hop varieties from the United States and Europe were analyzed with free choice profiling (FCP) and descriptive analysis (DA) sensory techniques to determine first what aromas are present in hops in general, and then to apply certain aroma characteristics to specific hop cultivars. The results from FCP were analyzed with generalized procrustes analysis to group similar attributes and products together. The results from DA were then used to determine how consistently these attributes can be used to differentiate between varieties.

*Bryan Donaldson graduated with a B.S. degree in biochemistry from Santa Clara University in 2009. He began graduate school at UC Davis in 2009, pursuing a master's degree in food science, with a focus on beer and brewing, working with Charles Bamforth. During the summer of 2010 he worked as a brewing intern at the Los Angeles brewery of Anheuser Busch-Inbev. He plans to have completed his degree by June 2011.*

**O-26**

**A survey of sensory science in the beer industry**

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Sensory science is the use of scientific principles to assess product perception and to quantify organoleptic responses through statistical analysis. It is an important tool for bridging the gap between consumer perception and analytics, including the measurements of pH, BU, and aromatic compounds. Therefore, sensory evaluation has assumed an ever-increasing role in the beer industry. Most commonly applied to quality assurance, sensory techniques can also be used in product development and research, including packaging or process changes. This study assesses the use of sensory science in the beer industry. A survey was distributed to sensory workers at varied brewery sizes. Participants were asked to identify the brewery for which they worked. This data was not reported but used only to eliminate the possibility of duplicate information. Workers were then asked to identify procedures used to assess organoleptic profiles for ingredients, in-process liquid, the final product, and competitors. Additionally, the issues and difficulties in applying sensory techniques at a brewery were solicited from the respondents. Finally, brewing academics were interviewed to provide information on the tools taught to their students in regards to sensory and beer evaluation. This study attempts to provide an overview of the current status of sensory science in the beer industry as well as the preparation of future sensory workers through academia.

*Annette Fritsch has been an active member of ASBC since 2004. She obtained her master's degree in the brewing laboratory at Oregon State University. Her primary focus was sensory research, with direct attention to bitterness perception from hops. She has presented at numerous professional meetings (ASBC, WBC, and IFT) and enjoys intriguing conversations about the beer industry and the study of perception. Currently, she is the sensory manager at the Boston Beer Company.*

**O-27**

**Acceptance of off-flavors in beer by common consumers**

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In recent years, the global beer market has known a substantial consolidation in market share and simultaneously a rather standardized type of beer emerged. Common off-flavors like diacetyl and dimethyl sulfide, stale flavors, as well as microbial-infected beers have become rare due to technological improvements as well as to high quality standards set by the global brewing companies. On the other hand, due to globalization and a prolonged distribution, beer faces a certain time of ageing before it reaches the consumer. This work shows the results obtained by a preference tasting including several off-flavors (diacetyl, dimethyl sulfide), forced aged beer, as well as linalool. Linalool was included as a flavor in the tasting trial, because it is known as an indicator substance for late-hopped premium beers. Additionally, concentrations of linalool are sub threshold in the standardized beers mentioned above. In the trial, each volunteer was presented a set of two beer samples. One was a traditional commercially available Bavarian style lager, the other one was the same beer spiked with a specific pure flavor or forced aged, respectively. Tasters were asked to state which beer they would prefer. The results show that fresh beer samples were not significantly preferred by consumers. Addition of off-flavors resulted in a significant lower preference of the beer samples. Also, the addition of linalool resulted in a decreased preference. In conclusion, this work shows that consumers seem to be used to aged beer. However, a differing flavor profile resulted in a lower preference.

*Julia Steiner was born in Munich, Germany. After school she started studying food technology and biotechnology at the Technische Universität München in Weihenstephan, Germany. After graduating with a Dipl.-Ing. (graduate engineer) degree in 2010, she joined Professor Becker's team at the Institute for Brewing and Beverage Technology as a Ph.D. student. Her main topics of research include dietary fiber, alternative fermentations, and the use of spent grain.*

**O-28**

**The detection of hop-derived aroma compounds in beer by using high-speed GC × GC TOF-MS and comparison of hop varieties in beer**

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Aroma compounds in hop have already been reported in many studies, especially terpenoids, esters, acids, and so on. Some of these compounds contained less-than-threshold concentration. However, these compounds may show influences on aroma or flavor in beer by the effect of other co-existing compounds in beer products. Compounds arise from hop, some move into beer products unchanged, but some are converted to different compounds during brewing processes, such as boiling or yeast fermentation. Therefore, the aroma characteristics of hop itself can be different from those in beer. So, we tried to detect such hop-derived compounds in beer in full detail by comparing the hopped beer and the unhopped beer using high-speed GC×GC TOF-MS. Furthermore, we have compared the differences of aroma characteristics and the compounds contained by changing the variety of hops, such as Saaz, Hallertau Mittelfuh, Tradition, Perle, and Cascade. In this study, the amount of each hop added was determined to adjust the concentration of linalool in each beer to be the same, because linalool shows strong influence on flavor intensity and characteristics on hopped beer. The difference of aroma profiles of each hopped beer indicates the genetic diversity and the phylogenetic relationships. Therefore, these studies should give brewers the useful information on the requirement of the characteristics of hops for designing new beer products and also give hop culturists ideas for variety development.

*Takako Inui graduated from Kyusyu University. She started her research career with Suntory Ltd. in 1989 at the Institute for Fundamental Research. Since 2002, she has been conducting research at the Institute for Beer Development on the development of brewing technology and the flavor science of beers, including the hop itself.*

**O-29**

**A comparative study of the functionality of hop hard resins extracted from different hop varieties**

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(1) Technische Universität München-Weihenstephan, Lehrstuhl für Brau- und Getränketechnologie, Freising, Germany

At its most simple, hop (*Humulus lupulus* L.) varieties are classified, according to their flavoring properties, as 'bittering hops' and 'aroma hops'. In numerous studies, detailed assessments of the quality parameters of both types have been carried out. Usually, bittering hops and aroma hops are compared and rated based on their brewing value and their contributions to beer quality. The brewing value of hops is primarily attributed to the flavor- and bitter-active compounds found in the resins. These resins are synthesized and accumulated in the lupulin glands of hops. Early work on the fractionation of hop resins, based on the solubility of resins in various organic solvents, classified them into soft resins and hard resins. Until now, research has primarily focused on studying the impact on beer properties of the major hop bitter acids (α- and β-acids) present in the soft resin. For this reason, little information is available on the functionality of the hard resin and for years it has been considered of no value. However, it is known that, besides the α-acids,

hops contain other constituents which can contribute to beer quality. It is the purpose of this work to determine the extent to which the hard resins contribute to the beer quality. Additionally, it is intended to establish if there are any significant differences among the hard resins extracted from the different hop varieties. Further, the functionality of this resin as a brewing product is examined, and finally the hard resin contribution to the microbiological stability of beer is assessed. To achieve all these, brewing trials were conducted in which the α-acids were replaced with a hard resin rich extract. In these laboratory-scale experiments, it was possible to determine that the hard resin contributes to the microbiological stability of beer. Furthermore, it was shown that addition of this resin confers a pleasant bitterness and a desired hoppy flavor which is a great contribution to the harmony and drinkability of beer.

*In 2008, Cynthia Almaguer completed her B.S. degree in biochemical engineering at Jacobs University, Bremen. She then started her graduate studies in a collaborative project between the Institute of Brewing and Beverage Technology (Professor Thomas Becker), TUM-Weihenstephan and the Department of Food and Nutritional Sciences (Professor Elke Arendt), University College Cork. Her research project aims to understand and reveal the contributions of hop hard resins in beer. A significant portion of her research activities are directed toward the investigation of the taste as well as the antimicrobial properties of hops.*

**O-30**

**Influence of hop fraction on the quality of adjunct beer**

HITOSHI TAKEMURA (1)
(1) Kirin Brewery Company, Ltd., Yokohama, Japan

This presentation reports the results of investigations into the impact of the form of hop fraction on the quality (flavor, taste, and bittering quality) of adjunct beer (60% malt and 40% corn syrup). The forms of hop fraction examined were T-90 pellets, $CO_2$ hop extract from T-90 pellets, and spent hops (hop residue from the manufacturing of $CO_2$ extract from T-90 pellets). Using the Deutsche Landwirtschaftliche Geselschaft (DLG) organoleptic evaluation method, the score for "fullness" in the beer brewed with T-90 pellets (beer A) was significantly higher ($P < 0.05$) than beer brewed with $CO_2$ hop extract (beer B). The scores for "flavor" and "taste" were higher for beer A than for beer B. The intensity of stale flavor perception was significantly higher ($P < 0.05$) in beer A than beer B. Beer brewed with spent hops (beer C) was found to have flowery and citrus flavors similar to those perceived in beer A and beer B. Beer C also possessed unique flavors resembling green leaves, wine, and blackcurrants. When beer B and beer C were blended, hop aroma perceptions and harmony of bitterness changed in proportion with the blending ratio. This suggests that polar compounds (hop glycoside, non-isohumulone bitter compounds, and polyphenols, etc.) contained in the spent hop fraction have a strong effect on the flavor and taste of adjunct beer. In a subsequent experiment investigating the influence of the spent hop fraction on adjunct beer, 4 types of adjunct beer were brewed using T-90 pellets (beer D), $CO_2$ hop extract (beer E), $CO_2$ extract plus spent hops added at the start of the boil (beer F), and $CO_2$ extract plus spent hops added at the end of the boil (beer G). Beer E had a markedly lower flavor quality than beer D, and the intensity of flavor, especially citrus flavor, was lower in fresh beer, whereas the intensity of citrus flavor in beers F and G was the same as in beer D. These results suggest that the spent hop fraction increased the flavor quality in adjunct beer. In force-aged beer, beer D displayed a higher stale flavor (mainly cardboard flavor) than beer E. The intensity of cardboard flavor was remarkably lower in beer F and G, and no different from that of beer E. These results indicate the influence of hop fraction on the quality of adjunct beer.

*Hitoshi Takemura has worked for Kirin Brewery Company Limited since receiving a master's degree in life science from Kyoto University in 2002. He worked in the Quality Assurance Department of the Tochigi brewery for three years and then entered the Laboratory for Brewing, where he conducted research on the use of hops in wort boiling. From 2008 to 2010 he worked as a guest researcher in Lehrstuhl fuer Brau- und Getraenke Technologie fuer Technische Universitaet Muenchen. Since August 2010 he has worked in the Brewing Technology Development Center.*

**O-31**

**Increase in hop utilization by the use of easily applicable technologies and their influence on resulting beer quality**

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(1) Technische Universität München-Weihenstephan, Lehrstuhl für Brau- und Getränketechnologie, Freising, Germany

Iso-α-acids are the major contributor to the bitter perception in beer. They contribute to over 85% to the overall bitterness of traditional beers. In the brewing process, however, only about 30% of the α-acids present in hops are isomerized and transferred into the finished beer. Although hop products cause only relatively little costs for breweries, many of them try to reduce costs and economic imponderability by saving in hopping technology. Several researchers suggested a pre-isomerization of hop prior to wort boiling. Although overall utilization rate could get increased by such technologies, the negative influence to beer quality and the need of plant-specific modifications has to be mentioned. In this paper, the influence of several techniques, namely a subdivided hop dosage, grinding of hop pellets prior to dosage, an increase in the pH value of wort, dosage of $CaSO_4$ or MgO, gassing of wort with $CO_2$, hopping of first wort, and dosage of silica gel, on utilization rate and beer quality is shown. All of these technologies are possible nearly without any reconstruction. It could be shown that an increase in hop utilization can lead to an improvement or at least a maintenance of beer quality. Pilot-scale trials were done to evaluate the influence of various treatment technologies to sensorial and analytical attributes. Particular attention is directed towards bitterness profiles of fresh and forced aged beers. All trials were done with reference to common brewed beers. The results presented in this paper provide a better understanding of the conversions during the brewing process and its influence on beer quality. Suitable approaches toward an improved yield of bitter acids and an improved bitter quality are shown.

*Sebastian Kappler received a Dipl.-Ing. degree in brewing and beverage technology from Technische Universitaet Muenchen in 2008. He began his employment with the Augustiner-Wagner brewery in Munich, Germany, as an apprentice to a brewer and maltster in 2000. After achieving the level of assistant, he started his studies on brewing science at the Technische Universitaet Muenchen. Since 2008 he has been working as a scientific employee at the Chair for Brewing and Beverage Technology in Weihenstephan. The topic for his doctoral thesis is the evaluation of the factors affecting the yield of isohumulones during preparation of wort.*

**O-32**

**PIE: The effect on a commercial scale by boiling hops separately from wort**

HISATO IMASHUKU (1)
(1) Asahi Brewers, Ltd., Japan

We have developed two new technologies for efficient and flexible wort boiling. They can reduce the total evaporation ratio during wort boiling, without the increase of undesirable or excessive flavors from malts or hops. Moreover, the isomerization of hop α-acids is improved. They are the "DMS-rest" and the "Pre-Isomeriser & Evaporator (PIE)." The removal of DMS is limited by the conversion from DMS-precursor (DMS-P), not by the evaporation of free-DMS itself. When the wort is heated up, the supply of steam is stopped, and the wort stands at a high temperature. This is the DMS-rest. During the rest, DMS-P is converted to free-DMS without more supply of steam. After the rest, the wort is boiled for a short time. Free-DMS is evaporated immediately, because it has already converted enough from DMS-P. However, using the DMS-rest method, some flavors from hops cannot be sufficiently removed, because of their higher boiling temperatures. And shorter boiling time leads to insufficient

isomerization of α-acids. Therefore, we developed equipment for boiling hops with hot water, separately from wort. We named it PIE. The energy consumption in PIE is slight, because the size is 1/50 of the wort kettle. After evaporation and isomerization in PIE, the hops is added to wort. PIE also improves the utilization of hops. We suppose that enough heat load and good extraction by strong agitation in PIE contributes to the isomerization of α-acids. By 2009, we have applied PIE and DMS-rest to our 5 breweries on a commercial scale. In 2010, we can reduce costs for energy by $1.1 million and for hops by $0.3 million. In the combination of DMS-rest and PIE, it is possible to take both of the optimums for wort and hops, at the same time, and independently of each other.

*Hisato Imashuku graduated with a degree in agricultural chemistry from the University of Yamaguchi, Japan. He began employment with Asahi Breweries, Ltd. in 1989 as a technical staff member in the brewing section. After he had worked at several breweries and in the laboratory, he was transfered to the Ibaraki R&D Promotion Office in 2001. He has been working at the Nishinomiya R&D Promotion Office, Production Technology Center, Asahi Breweries, Ltd. since 2008.*

**O-33**

**Wort FAN—Its characteristics and importance during fermentation**

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FAN (free amino nitrogen) is the sum of the individual wort amino acids, ammonia, and small peptides (mainly di- and tripeptides). FAN is an important general measure of yeast nutrients which constitute yeast-assimilable nitrogen during wort fermentation. Even if attenuation of wort carbohydrates proceeds normally, the same quality of beer is not always guaranteed to be produced, suggesting that the sugar content of wort alone is not a good indicator of yeast fermentation performance. The wort's nitrogen content is used by the yeast in order to accomplish its metabolic activities which include the synthesis of de novo amino acids leading to the synthesis of structural and enzymatic proteins. FAN has been regarded as a better index for the prediction of healthy yeast growth, viability, vitality, fermentation efficiency. and consequently beer quality and stability. Studies have identified "marker" amino acids and other wort nitrogen constituents that are responsible for stimulating and reinforcing fermentative activity. In addition, synergetic effects between wort free amino acids, small peptides. and ammonia in terms of improved yeast fermentation efficiency have been examined.

*Graham Stewart is the Emeritus Professor of Brewing and Distilling at Heriot-Watt University, Edinburgh, Scotland, and Special Professor in Bioethanol Fermentation at Nottingham University, England. He was the director and professor of the International Centre for Brewing and Distilling, Heriot-Watt University, from 1994 to 2007. From 1969 to 1994 he held a number of technical positions with Labatt's in Canada and from 1986 to 1994 was its brewing technical director. He was the president of the Institute of Brewing (now the Institute of Brewing and Distilling) in 1999 and 2000. He is also a member of ASBC and MBAA. He holds fellowships in the IBD, the Institute of Biology, and the American Academy of Microbiology. He has more than 250 publications (books, patents, review papers, articles, and peer-reviewed papers) to his name. Since his retirement he has established a consulting company—GGStewart Associates—and has an office in Cardiff, Wales. As well as being awarded the IBD Horace Brown Medal (2009), he has also been presented with the ASBC Award of Distinction (2008), the MBAA Presidential Award (1983 and 1998), the MBAA Award of Merit (2009), and the Society of Industrial Microbiology Charles Thom Award (1988).*

**O-34**

**Investigation of essential nutrients for yeast propagation and fermentation for low-malt– and no-malt–type beer beverages**

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During brewing low malt or non-malt beer-like beverages, we sometimes observe sluggish fermentation. Sluggish fermentation tends to increase off-flavors such as sulfur compounds, and they are generally considered to be caused by the deficiency of certain essential nutrients derived from malt. We previously reported several phenomena caused by the shortage of nutrients such as amino acids and vitamins. For example, reduction of tryptophan or vitamin $B_6$ levels in wort induces the production of indole (2009 ASBC Annual Meeting). Many research projects on the nutrition of yeast such as amino acids, vitamins, minerals, and lipids have been conducted; however, previous reports are mainly focused on the additional effect on wort equipped with high-gravity brewing or low malt quality. In this study, we used an omission test to evaluate the essential nutrients on yeast propagation and fermentation. First, we made a synthetic medium consisting of maltose syrup, amino acids, and vitamins. Second, we performed yeast propagation and fermentation test using these media and measured yeast physiological state and products such as esters and organic acids. We then compared the essential nutrients between the propagation process and the fermentation process, and found that they are not necessarily identical. For example, shortage of inositol level induces irregular budding during both propagation and fermentation; on the other hand, thiamine and Vitamin $B_6$ are necessary for the production of suitable levels of beer flavor such as esters during fermentation, but not during propagation. In this presentation, we summarize the nutrient conditions necessary for yeast propagation and fermentation, and propose typical nutrient conditions required for appropriate propagation and fermentation.

*Atsushi Tanigawa received an M.S. degree from the Department of Agricultural and Environmental Biology, Tokyo University. He found employment with Sapporo Breweries, Ltd. in 2005 as a microbiologist in the Frontier Laboratories of Value Creation.*

**O-35**

**Interaction of nitrogen composition on aroma-active metabolites and flavor profiling**

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Organoleptic characteristics of beer mainly depend on the aroma-active substances produced by yeast during fermentation. In particular, volatile higher alcohols and esters are determined by the nitrogen and carbohydrate composition of fermentation wort. Especially amino acid assimilation by yeast influences the synthesis of higher alcohols via the Ehrlich pathway. Of all secondary metabolites, higher alcohols are of great interest, because they are generally produced by yeast in the highest absolute concentrations. Furthermore, esters whose syntheses are linked to the concentration of their corresponding alcohol are very important because of their responsibility for the highly desired fruity, honey, and perfume-like aroma in beer. Even though they are only present in trace quantities they can affect beer flavor well below their threshold value. However, the absolute amount of aroma-active compounds is not really relevant for the flavor of fermented alcoholic beverages. The relationship between the different volatiles is more important. This can be explained by synergy effects of the aroma-active substances. Thus, it is possible that very low aroma concentration can regulate sensory profiles. Many studies have been carried out to optimize the technical parameters in brewing process in order to control beer flavor. Nevertheless, few studies

have been carried out on the effect of specific substrate composition in the media to create certain aroma profiles in beer. Therefore, an exact defined fermentation media was developed to consequently diversify important substrate compounds. Here, amino acid variations premeditated by a design of experiment have been performed in fermentation trails in laboratory scale using lager and ale brewing strains. Significant results in amino acid composition have been found by measuring aroma-active metabolites via GC-FID. This might help to control defined amounts of flavored substances in fermented beverages and how it is possible to generate specific sensory effects.

*Susanne Procopio was born in Gießen, Germany. She graduated with a Dipl. Agr.-Biol. degree from the University of Hohenheim in Stuttgart, Germany, where she also prepared her diploma thesis in molecular biotechnology in 2008. Since 2009 she has been a Ph.D. student at the Lehrstuhl für Brau- und Getränketechnologie, Technische Universität München, working in the field of yeast genetics and aroma profiling.*

**O-36**

**An approach to brew beer vinegar with waste beer from spent yeast**

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Spent yeast slush is the by-product of brewing, the yield of which is about 1.5% of total beer production. The yeast is separated from the spent yeast slush which can be utilized generally, while the rest of the waste beer can be used as raw material to produce beer vinegar. However, it's difficult to maintain the abiotic stability of it as goods. In the present report, we studied the abiotic turbidity of beer vinegar. The waste beer was treated with enzymolysis, heat treatment, and clarification so as to enhance the abiotic stability. We also studied the technological parameters of mixed bacteria fermentation which could improve the beer vinegar flavor. biotic turbidity is a key factor that affects the quality of beer vinegar. The appearance of abiotic turbidity is associated with the high content of high-molecular-weight protein and polyphenols. Papainase was used to deal with the waste beer at the optimal condition: zymolyzing temperature was 55°C, zymolyzing time was 120 min, and enzyme dosage was 4,000 U/g. Then the liquid was heat-treated by high temperature. The optimal conditions included boiling temperatures of 100°C, carrageenan addition of 60 mg/L, and heat treating time of 50 min. After fermentation, the beer vinegar was clarified with PVPP which could reduce the polyphenols further. The flavor is another factor which has an impact on the quality of the beer vinegar. Aroma-producing yeast xjb45 was pitched together with Acetibacteria AS1.41 as mixed fermentation in order to improve the aroma of the beer vinegar, which could provide the metabolic pathway of the flavor substances as well as the enzymes needed. The optimal conditions of beer vinegar fermentation included the ratio of AS1.41 to xjb45 of 1:1.5, fermentation temperature of 30°C, and inoculum of 15%. The beer vinegar prepared by this technique was of improved flavor with the characteristics of malt and apple, and it also had a good abiotic stability. This way to utilize the waste beer from spent yeast provided by our study could effectively reduce environmental pollution.

*Guangtian Zhou is a professor in bioengineering, and also a director of the China-Germany Brewing Technical Service Center in the Shandong Institute of Light Industry. Guangtian received his B.S. degree in bioengineering from the Shandong Institute of Light Industry in Jinan, China. He worked in the Jinan Beer Group from 1982 to 1987 as a brewer. From 1987 until 1988, he studied at Doemens Brewing Akademie in Munich, Germany, as a scholar. He then worked in the Jinan Beer Group as a chief engineer. Since 1994, he has been working in the Shandong Institute of Light Industry as a professor. He is now the director of the China-Germany Brewing Technical Service Center. Guangtian is also an editor of* China Brewing*, a famous journal in China, and a council member of the Microorganism Association of Shandong, China.*

**O-37**

**Chelating beer soluble iron (BSI) in diatomaceous earth (DE) with hop acids**

PATRICK L. TING (1), Fran Saunders (2), Gregory Casey (3), David Ryder (1)
(1) MillerCoors, Milwaukee, WI; (2) Miller; (3) MillerCoors, Golden, CO

Diatomaceous earth (DE), a filter aid, has been used by brewers around the world to produce brilliantly clear beer. However, iron, copper, and metals present in the DE can leach into the liquid and deteriorate the beer flavor. Trace Fe or Cu and a trace level of oxygen mediate free radical formation, analytically resulting in higher ESR/PBN-T150 values correlating with the more rapid development of stale flavors in beer. Brewers and brewing scientists around the world are looking at alternative technologies to replace DE filtration, such as Divergan HM or membranes. However, one stumbling block is the cost of these alternative technologies. U.S. Patent 4,187,174 (Feb. 5, 1980) disclosed that a treatment of diatomaceous earth filter aids with an acid (inorganic acids, acetic acid, and oxalic acid) resulted in a beer soluble iron (BSI) content of less than 0.01–0.005% (100–50 ppm). We are developing a novel streamline treatment of DE with hop acids (such as tetrahydro iso-α-acids) and $H_3PO_4$ during filtration to prevent/reduce soluble iron in DE from leaching into beer. This results in a lower ESR intensity increase versus normal DE filtered beer, which leads to a better flavor-stable product.

*Patrick L. Ting, who holds a Ph.D. degree in organic chemistry, is currently working in Brewing and Research, MillerCoors, Milwaukee, WI. His area of research is in hops and advanced hop product development, including better understanding of the attributes of hops to improve hop flavor and flavor stability, hop chemistry to enhance product and brand performance, and applied hop science to improve product quality. He has developed novel hop products and new hop technologies and is guiding the company's Watertown Hops Company facility to improve processes and the quality of hop products.*

**O-38**

**Control of hop aroma in beer by hop boiling conditions**

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Linalool is an important hop aroma compound in beer. Therefore, it is essential to control the concentration of linalool in beer for achieving the target quality, particularly the hop aroma, stably. In order to rationalize the factors which may affect the concentration of linalool during the boiling process, we have carried out model boiling tests under various conditions as follows: 1) the timing of the late hopping, 2) the gravity of the wort, 3) the pH of the wort, and 4) the malt ratio of the wort. The concentration of linalool in the boiled wort was analyzed. We also have focused on hop aroma compounds other than linalool to evaluate their organoleptic characteristics in beers. The isomerization rate of the α-acids and the amount of hop bitter compounds were also examined carefully, because we have observed a case where the isomerization of the α-acid was incomplete as a result of insufficient boiling time. From this information, it is suggested that the characteristics and the intensity of the hop aroma in beer would be controllable by adjusting hop boiling conditions.

*Mariko Ishimaru received her M.S. degree from the Department of Agriculture, Kyushu University, and has been engaged in research on the improvement beer quality through hop science at the Beer Development Department of Suntory Liquors Ltd. since 2008.*

**O-39**

**Beer maturation: When is a beer mature from the dry hop perspective?**

URS WELLHOENER (1), Annette Fritsch (1)
(1) Boston Beer Company, Boston, MA

During storage, there are different ways to determine the right maturation time for a beer. From the analytical perspective, parameters like diacetyl or acetaldehyde are the main focus. Additionally, beers are tasted at certain times to evaluate for the presence of typical "green beer" flavors. This is used to indicate if maturation has been achieved. For breweries without a GC, sensory is the only tool to determine if the beer is ready for packaging. However, both evaluating techniques do not focus primarily on the changes in dry hops aroma and flavor. Our goal was to identify the best "dry hop maturation time" for a lager beer. If the amount of time on dry hops is inadequate, there will be a poor release of valuable hop oils; yet, too long dry hopping times can result in "cheesy" beers. However, to make this applicable, a compromise must be considered for the right maturation time between the typical maturation parameters and the optimal time for dry hopping. This research evaluated the differences over time of hop impact due to the changes in a lager beer's composition throughout fermentation. Hops were steeped for 28 days, and data was collected at 5-day intervals. A variety of hop aroma compounds, including myrcene, linalool, and limonene, and the hop acids were monitored. In addition to analytics, the product was also evaluated sensorially. The aromatic and bitterness impact of the liquid was rated by a panel of experts. Data were collected in replicate, and a principle components analysis was performed to evaluate how the liquid changed during fermentation. Additional comparisons of the analytics were completed to assess optimum extraction times and overall hop impact on the product. A compilation of chemical and sensory results was used to evaluate the change-rates in hop impact during lager beer fermentation.

*Urs Wellhoener is the corporate manager for yeast and fermentation for the Boston Beer Company, having joined the company in 2007. His focuses are yeast management and microbiology. He is a technical graduate as brewer and maltster (1991–1993) and received a Dipl.-Ing. degree from the Faculty of Brewing and Food Technology of the Technische Universität München-Weihenstephan (TUM) in 1999. After graduation in 1999, he was a project manager on a yeast project at Veltins Brewery, Meschede-Grevenstein (1999–2000). Between 2000 and 2007 Urs was a scientific assistant and doctorate at the Chair of Brewing Technology II at the Weihenstephan Center of Food and Life Sciences, TUM. Urs received his Ph.D. degree for his studies on yeast physiology during fermentation and propagation. During this time he also worked for Muellerbraeu, Pfaffenhofen, Germany, as QC manager.*

**O-40**

**Biotransformation of monoterpene alcohols by lager yeast and their contribution to the citrus flavor of beer**

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Various beers contain many flavor compounds derived from barley malts, hops, and yeast fermentation. Among these flavor compounds, terpenoids are mainly derived from hops. Especially, linalool, one of the monoterpene alcohols, has been regarded as an important factor for a hop-derived beer flavor. In this report, we focus on contributions of other monoterpene alcohols (geraniol, β-citronellol, nerol, and α-terpineol) to hopped beer flavor. Several researchers have reported that monoterpene alcohols are biotransformed by brewing yeasts during beer fermentation, and that geraniol is mainly transformed to β-citronellol. First, we investigated biotransformation of monoterpene alcohols during fermentation of hopped beer by using various hop varieties. As a result, geraniol drastically decreased during the first 3 days. β-Citronellol was almost absent in wort and gently increased during total fermentation period. The concentrations of geraniol and β-citronellol in finished beer increased depending on the initial concentration of geraniol in wort. We next examined flavor characteristics of monoterpene alcohols and found that there was an additive effect among linalool, geraniol, and β-citronellol. The test-brewed beer containing these three monoterpene alcohols had a citrus flavor. Therefore, we carried out the screening of various hop varieties and selected Citra as a geraniol-rich hop. The use of Citra was effective for enriching the concentration of geraniol and β-citronellol in the finished beers and this Citra beer had a strong citrus flavor. We evaluated the synergy of geraniol and β-citronellol under coexistence with excess linalool, simulating the composition of the three monoterpene alcohols in the Citra beer, and found that the flavor impression became lime-like citrus by coexistence of all three monoterpene alcohols. From these results, it was suggested that geraniol metabolism by brewing yeasts contribute to the citrus flavor of beer. In addition, the variation on geraniol contents among the U.S. hop varieties is also discussed.

*Kiyoshi Takoi graduated from Tohoku University with an M.S. degree in agricultural chemistry in 1989 and joined the Brewing Research Laboratories of Sapporo Breweries, Ltd. as a biochemist. From 1989 to 2002, he worked on brewing chemistry and mainly investigated beer foam stability. During 2002–2005, he evaluated the brewing properties of malts and hops using the pilot malting and brewing plants in the Production & Technology Development Center. In 2006, he managed product development in the New Product Development Center. During 2007–2008, he worked in the Frontier Laboratories of Value Creation as a lead research brewer and mainly investigated hop-derived flavor compounds. At present, he is working in the Value Creation Department of Sapporo and developing new products. He received a Ph.D. in agricultural chemistry from Tohoku University in 2011.*

**O-41**

**First wort hopping and its influence on hop utilization rate and resulting beer quality**

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Hop is an essential ingredient for beer. Iso-α-acids are the main contributor of bitterness in it. Unfortunately, the utilization rate up to finished beer amounts only to about 30% of the α-acids dosed to the wort before and during boiling. Several technologies to increase hop utilization were suggested within the past few years. Nevertheless, often a negative impact to beer quality was reported. Also, essential oils present in hops can play an important role in beer flavor. Aroma impressions like fruity, flowery, and citrusy mostly are based on those hop compounds. Unfortunately, because of evaporation the transfer rate is usually quite low. Depending on time and intensity of wort boiling, in the majority of cases only traces of those compounds can be found in finished beer. To raise the amount of aroma-active hop oils, various technologies are used. Usually, a late hop dosage at the end of boiling or a dosage directly into the whirlpool is done. Another possibility is a dosage to the beer during storage. All of these techniques create a unique hop aroma. Although already in the beginning of the 20th century a dosage of hops to the first wort during lautering to increase bitterness and hop aroma was mentioned, nearly no knowledge exists about the influence of that early hopping on hop aroma and bitterness. In this paper, the influence of variations in the early-hopping technology on utilization rates and beer quality is presented. It was shown that a dosage of hops at that early stage of wort preparation can lead to a very unique hop aroma and also bitterness perception can vary. Pilot-scale trials were done to evaluate the influence of a first wort hopping technology on sensorial and analytical

attributes. Particular attention is directed towards the aroma and bitterness perception of fresh and forced aged beers. The results presented in this paper provide a better understanding of the conversions during the brewing process and its influence on beer quality. Suitable approaches toward an improved yield of bitter acids and an improved bitter quality as well as aging stability are shown.

*Sebastian Kappler received a Dipl.-Ing. degree in brewing and beverage technology from Technische Universitaet Muenchen in 2008. He began his employment with the Augustiner-Wagner brewery in Munich, Germany, as an apprentice to a brewer and maltster in 2000. After achieving the level of assistant, he started his studies on brewing science at the Technische Universitaet Muenchen. Since 2008 he has been working as a scientific employee at the Chair for Brewing and Beverage Technology in Weihenstephan. The topic for his doctoral thesis is the evaluation of the factors affecting the yield of isohumulones during preparation of wort.*

**O-42**

**Impact of various levels of unmalted oats on the quality and processability of mashes, worts, and beers**

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The brewing industry is facing an ever-increasing challenge to become more cost-effective, while at the same time maintaining or improving product quality. Brewing with unmalted oats can reduce the costs of raw materials. However, the replacement of malted barley with unmalted oats can also adversely affect the quality and processability of mashes, worts, and beers. In this study, brewing with unmalted oats (0–40%) and malted barley was carried out in a 60-L pilot plant. The impact of various levels of unmalted oats on mashing, lautering, and fermentation performance was monitored in detail using standard analysis, Lab-on-a-chip capillary electrophoresis for protein profiling, and a rheometer to determine viscous characteristics. The quality of the final beers was evaluated using standard methods according to EBC and MEBAK. In general, the processability of mashes containing up to 40% unmalted oats was comparable to that of the reference brew (100% barley malt) despite their higher viscosities. However, the extract and free amino nitrogen content of worts significantly decreased with increasing levels of unmalted oats whereas their fatty acid content clearly increased. The final beers exhibited lower foam stabilities but good sensory properties.

*Birgit Schnitzenbaumer did an apprenticeship as assistant tax consultant and worked in this job before she studied brewing and beverage technology at the Technical University of Munich in Weihenstephan, Germany. During her studies, she completed several internships in breweries and did her master's thesis on the effect of malting on the protein profile of proso millet (*Panicum miliaceum *L.) at the School of Food and Nutritional Sciences of the University College Cork, Ireland. Birgit graduated with a Dipl.-Ing. (M.S.) degree in brewing and beverage technology in 2009 and started her Ph.D. project on the application of novel and industrial enzymes when brewing with unmalted cereals at the University College Cork in November 2009.*

**O-43**

**Development of brewing technology using barley flake with improved productivity**

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Several major problems have been identified in barley brewing: limitation of free amino nitrogen, low extract yield, and prolonged mash filtration and dehydration of spent grain. Brewing technology for the use of malt with barley flake made from barley through the process of de-husking, steaming, rolling, and drying was investigated with the goal of improving productivity with regard to the yield of flake extract and the dehydration of spent grain. In order to maximize the extract obtained from barley flake, an accurate evaluation method for flake extract quality was based on that for EBC malt extract in the laboratory. Among the flake analyses, "water absorption rate" was identified as an indicator with high correlation to flake extract quality and is a rapid determination that can be performed on-site in flake factories. The standard of water absorption rate determined in our study was applied by flake manufacturers. The significance of the water absorption rate was confirmed in comparative brewing studies evaluating yield. The physical properties of barley flake with poor dehydration of spent grain were investigated; surface porosity and heterogeneous thickness were found. Further, the relatively low water absorption suggested that poor starch gelatinization was the result of poor steam infusion. Based on the data of water absorption rate, modifications to optimize the steam infusion process resulted in improved dehydration of spent grain in breweries.

*Tsutomu Ueda studied biotechnology at Osaka University. Tsutomu has been employed by Asahi Brewery Ltd. since 1993 and has held the following positions: Fukusima brewery in the mashing section, primarily responsible for development of a bottom-entry mashing-in system (presented at 26th EBC Congress) (1993); Asahi Beer Malt Ltd. as a malting supervisor (1995); Asahi Brewing R&D Lab as chief in the Quality Assurance Section (1997); Brewing Research International (BRi) as a visiting researcher (1999); Asahi Brewing R&D laboratory as a malt specialist, primarily responsible for development of malting technologies for extending beer freshness (presented at 28th and 31st EBC Congresses, 2002 MBAA Convention, 2004 World Brewing Conference) (2000); Asahi Research Laboratories of Brewing Technology as chief researcher (2007); secretary general of BCOJ (Brewery Convention of Japan) (2008–2009); and Production Technology Center, R&D Promotion Office, Asahi Breweries, Ltd. (2010).*

**O-44**

**Changes in protein compositions during malting of common wheat (*Triticum aestivum* L.) and their influence on beer quality**

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During the malting process, high molecular weight storage proteins are degraded by proteolytic enzymes to both mid-size and small peptides as well as to amino acids. Until now, only a little knowledge has existed about the chemical pathways and the factors that influence those degradation reactions during malting. In this paper, a fundamental study on protein changes taking place during the malting of common wheat (*Triticum aestivum* L.) is presented. Changes in content and composition of molecular fractions were investigated during the steeping, germination, and kilning process. Pilot-scale malting trials with a standard malting regime (7 days of germination at 15°C with a steeping degree of 45%) were done in order to ensure a comparable malt modification at the end. Samples taken of every single malting step and additionally daily during germination were analyzed to get a deeper insight into proteolytic breakdown which takes place during the malting process. Variations in protein content and composition in relationship to the degree of modification are shown. The malt was analyzed according to ASBC and EBC methods. Protein fractions were analyzed using a lab-on-a-chip technique, which separates the proteins—based on their molecular weight—by capillary electrophoresis, and was supported by using two-dimensional gel electrophoresis. In addition, the impact of malting on the ultrastructure of wheat was evaluated using scanning electron microscopy

(SEM) and confocal laser scanning microscopy (CLSM). Using those techniques, it is possible to visualize the changes in structure and thereby to get a deeper insight into the kernel itself. All results were compared to the changes taking place during the malting of barley. By interpretation of those results, possibilities for the optimization of final beer quality depending on the degree of modification of the used malt can be shown.

*Andrea Faltermaier studied food technology at the Technische Universität München (TUM), Weihenstephan, Germany. She performed her diploma thesis work at the Lehrstuhl für Brau- und Getränketechnologie, TUM-Weihenstephan. Since 2009 Andrea has been a Ph.D. student at the University College Cork (UCC), and she received the InBev-Baillet Latour Scholarship in Brewing and Malting. Her Ph.D. project, a cooperation between UCC and TUM, deals with studies on the application of wheat in brewing and functional beverages.*

**O-45**

**Practical brewing with unmalted barley and Ondea® Pro: A craft brewer's perspective**

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The feasibility of brewing superior-quality beer utilizing 100% unmalted barley and exogenous enzymes has been a subject of interest for brewmasters for well over 50 years. Historically, issues with turning this quest into reality have ranged from difficulties with milling the barley to a suitable particle size for enzymatic action, low levels of FAN in the wort, lautering and filtration issues, and colloidal instability, high VDK production, and grassy, grainy off-notes in the final beer. In 2009, Novozymes launched a new product, Ondea® Pro, which is an enzymatic solution that allows brewers to brew quality beer utilizing 100% unmalted barley, with typical unit operations found in standard breweries. That is, implementation of Ondea® Pro would not entail any additional or alternative capital expenditures for the brewer. However, when Ondea® Pro was developed, and operating conditions for milling, mashing, and lautering were devised, it was targeted for the brewer who possessed a fully automated and contemporary brewhouse. But what about craft and microbrewers who may have less-sophisticated brewing equipment? If a craft brewer who has a simple two-roller mill, mash-tun without temperature control or stirring, or a separate lauter-tun wanted to brew beer with unmalted barley and Ondea® Pro, what conditions would be employed? Could you successfully brew beer with unmalted barley and Ondea® Pro in the typical brewhouse of a craft brewer? In this paper, we will describe the practical aspects of brewing beer with unmalted barley and Ondea® Pro at a local craft brewer in North Carolina, looking at milling, mashing, and lautering versus what is typically done at a large brewer. The final product produced at the craft brewery was subjected to full sensory descriptive analysis and analytical analyses (esters, alcohols, organic acids, foam, haze, etc.) and was compared to an equivalent beer produced at that brewery using malt. Similarities and differences in sensory and analytical profiles of both beers will be compared and contrasted.

*David Maradyn is currently senior scientist-customer solutions, brewing with Novozymes North America, Inc. based in Franklinton, NC. He received his Ph.D. degree in organic chemistry from the University of Western Ontario, London, ON, Canada, in 1996. He spent 14 years with Anheuser-Busch InBev nv/sa, initially as a post-doctoral fellow with the Advanced Research Department of Labatt Brewing Company Limited in London, ON, and then as head of the Global Chemistry Development Laboratories in Leuven, Belgium. David has served ASBC as a member of various technical subcommittees, chair of of several technical subcommittees, chair of the Technical Committee, and member of the Board of Directors. He is currently editor of the A*SBC Methods of Analysis *and chair of the Emerging Issues Committee.*

**O-46**

**Functional beverages based on malted cereals and pseudocereals**

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In recent years, a number of novel innovative beverages have been launched. Due to growing consumer awareness of the negative impact of malnutrition in western countries, novel drinks based on natural raw materials have attracted a growing interest. Malted grains and natural fruit juices are especially suitable for the production of such beverages as they are generally considered as positive and healthy food ingredients. At the same time, stricter limits concerning drunk driving have led to a growing interest in non-alcoholic beers. This paper presents a concept to create a novel malt-based beverage using lactic acid fermentation. Wort is produced using existing brewing equipment and is subsequently fermented by selected strains. The resulting fermentation products are mixed with different fruit juices and carbonated, resulting in well-balanced, refreshing drinks. A new way to create a non-alcoholic beer is the use of stopped fermentation coupled with controlled lactic acid fermentation. Hops is added after fermentation and thus the microbiological stability is improved. Sensory evaluation of both beverages was done by a trained tasting panel to investigate flavor stability. Fresh and forced aged samples were analyzed. Stale flavor compounds were measured using GC-FID and GC-MS. The results obtained for these two new beverages were compared to a range of commercially available malt-based beverages and non-alcoholic beers.

*Moritz Krahl was born in Schwetzingen, Germany. After passing the German Abitur (A-levels) in 2000, he began studying brewing and beverage technology at Technische Universität München in Weihenstephan, Germany. In 2004 he graduated with a B.S. degree and in 2005 with a Dipl.-Ing. (graduate engineer) degree. From 2005 to 2010 Moritz did his Ph.D. work at the Institute for Brewing and Beverage Technology in Weihenstephan (under Professors Back and Becker). In May 2010 he joined MEG as engineer for plant and process optimization.*

**P-47**

**"Always optical" modern oxygen management in breweries**

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(1) Norit Haffmans, Venlo, The Netherlands

A growing number of breweries and brewing groups are standardizing oxygen ($O_2$) measurement using optical technology. Compared to traditional $O_2$ measurement, optical $O_2$ measurement reduces operating costs as it requires less maintenance and calibration, provides better measuring stability, and has a rapid response time. The versatility of optical $O_2$ measurement allows it to be used throughout the brewery in areas such as the brew house, filling, carbon dioxide ($CO_2$) recovery, and wastewater treatment. Examples of areas where optical $O_2$ measurement is applied include wort aeration, after aeration monitoring dissolved $O_2$ content to assure optimal conditions for fermentation. Fermentation process, the $CO_2$ gas produced can be recovered, purified, and liquefied. Using optical $O_2$ technology to monitor as well as state-of-the-art technology to process the gas results in knowledge about the source of the $CO_2$ gas, lower $CO_2$ costs, and a reduction of $CO_2$ emissions. Filtration and filling, following the fermentation process, it is important to monitor and prevent $O_2$ pick-up during filtration and before filling. Faster than traditional measurement, optical $O_2$ measurement reduces product loss and increases efficiency with shorter switch over times. Packaging, even if the $O_2$ quantity in the beer or beverage is within specifications, packaging will affect the total $O_2$ enclosed in a package. The total package oxygen (TPO) has a major influence on a product's shelf life and flavor stability and can only be measured in the package. New insight on TPO based on the differentiated $O_2$ measurement (head-space $O_2$ and dissolved oxygen [DO]) compared to the traditional method of calculating DO × Z will be shared. The innovative optical $O_2$ measurement technology achieves a fast

and accurate picture of the entire brewing or beverage production process. This results in quicker response times, an immediate reduction of product losses, and reduced operating expenses.

*Frank Verkoelen completed mechanical engineering studies at HTS Venlo in 1982 and began working for Haffmans BV as a project engineer for $CO_2$ recovery in 1984. Frank moved to the R&D Department in 1987 and over time became the R&D manager. In 2001 he became the product manager, QC and in 2004 became senior product manager responsible for QC and in-line equipment.*

**P-48**

**A novel homogeneous enzyme immunoassay for rapid on-site analysis of deoxynivalenol (DON) in grain**

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A new on-site test for deoxynivalenol (DON) was developed using a novel homogeneous enzyme immunoassay (HEIA) method. The test mechanism is described in detail and data is presented comparing the test's performance with commercial ELISA kits using grain samples (barley, malted barley, and wheat) naturally contaminated with DON at levels determined by HPLC and GC-MS analysis. The accuracy and precision of the DON HEIA test was found to be consistently equivalent to the corresponding ELISA systems. These results indicate that the new HEIA test can be effectively used for on-site DON testing and offers additional advantages of speed and simplicity.

*Sherman Chan received his bachelor's degree from the National Taiwan University and master's degree in cereal science and technology from North Dakota State University, Fargo. Sherman was employed at the Fleischmann Malting Company as quality control lab manager and then at the Pabst Brewing Company as a principal research chemist. Sherman joined Rahr Malting Company in 1980 as the technical director in charge of research and quality control until his retirement in 2006. He has been short course instructor for ASBC and MBAA and has worked as a malting consultant and short course instructor for the U.S. Grains Council to promote U.S. barley in Asia and South America. He has been a member of ASBC, MBAA, the AMBA Technical Committee, and IoB. He has served ASBC on the local and national levels. In addition to serving on technical subcommittees and the Technical Committee, he has served as president-elect, president, and past president of ASBC. During the past few years, he has worked as a technical consultant for the ThermoFisher Scientific Clinical Diagnostics Division.*

**P-49**

**A simple fermentation monitoring and control system**

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We present a simple approach for continuous monitoring of beer and other alcoholic fermentations by measuring carbon dioxide evolution. Measuring the $CO_2$ evolution rate can help estimate extract consumption and alcohol production in a continuous manner with simple and relatively inexpensive instrumentation (FermAT™). The technique can be used to "fingerprint" fermentations in a brewery and recognize early any deviations in fermentation performance. Moreover, with the FermAT™ system, it is possible to precisely control beer carbonation at the end of fermentation, prior to harvesting fermentors. The technology could potentially eliminate the need for secondary carbonation adjustment operations in the brewery.

*Murthy Tata is the founder and president of QuantiPerm, LLC. QuantiPerm has developed innovative instrumentation and methods for rapid analytical techniques related to barrier packaging development. QuantiPerm operates a testing laboratory and consults for the food, beverage, biotechnology, and consumer products industries. Murthy was at Miller Brewing Company between 1994 and 2000, working in all areas—brewing, fermentation, beer processing, and packaging. Subsequent to his tenure at Miller, Murthy worked at Motorola Life Sciences between 2000 and 2002 in the development of DNA biochip platforms for gene expression and genetic polymorphism analyses.*

**P-50**

**Application of dynamic light-scattering technique to detect the primary gushing potential from barley to finished beer**

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Gushing is the spontaneous and wild over-foaming of over-carbonated beverages that occurs at the opening of the container without any shaking. Primary gushing is related to raw material contaminated by filamentous fungi. These latter produce amphiphilic proteins called hydrophobins that interact with carbon dioxide bubbles leading to over-foaming. Up to now, to determine the gushing tendency of a malt batch, most beer producers have used the modified Carlsberg test (MCT), where a determined volume of sparkling water is replaced by the same volume of an aqueous malt extract. However, the precision and the reproducibility of this methodology have been subject to controversy. Recently a new method based on the dynamic light-scattering (DLS) technique was developed in our lab to characterize the primary gushing potential of carbonated beverages. This technique was first applied only on the final product (i.e., bottled or canned beer). It appeared that the main difference between a gushing and a non-gushing beer was the presence of particles with a diameter around 100 nm only in the gushing beer. The objective of the present work was then to apply this new method on earlier-stage products of the malting and brewing processes. The Congress mash method was used to produce wort from non-contaminated and contaminated malts and from a blend of non-contaminated malt and contaminated barley. The MCT was carried out by replacing 20 mL of sparkling water from a 1-L bottle ($CO_2$ at 7 g/L) by 20 mL of the worts obtained from the different malt and barley samples. After 3 days of agitation (horizontal, 150 rpm, 20°C), the bottles were opened and the over-foaming amount was determined by weighing. The wort/sparkling water samples were then centrifuged (4,000 × *g*, 10 min) and naturally degassed (i.e., at room temperature and under atmospheric pressure) until the $CO_2$ concentration reached approx. 1.7 g/L (equilibrium value at 25°C and under atmospheric pressure). After degassing, the size of particles present in the different samples was determined by DLS. The MCT results showed that worts produced from contaminated raw material (i.e., contaminated malt or blend of non-contaminated malt and contaminated barley) had a clear gushing tendency and DLS allowed us to detect the presence of particles with a diameter around 100 nm only in these gushing samples. Our results thus tend to confirm the applicability of DLS as a new method to characterize the primary gushing potential of raw materials.

*Sylvie Deckers received an M.S. degree in chemical bioengineering from ULg-Gembloux Agro-Bio Tech (Gembloux, Belgium), with honors, in 2008. Her master's thesis was on the "Possible Influence of Surfactants and Proteins on the Efficiency of Microbiological Surface Sampling." Since February 2009, she has been active as a Ph.D. student at the Catholic University of Leuven (Belgium) within the research consortium of KULeuven-LFoRCe and $M^2S$ in the Centre for Malt and Beer Sciences under the supervision of Professor Derdelinckx. Her topic is on the comprehension of the primary gushing phenomenon and, more specifically, on the interaction between $CO_2$ bubbles and amphiphilic contaminants such as hydrophobins. In 2010, she had a paper published in* Brewing Science *explaining her hypothesis of the primary gushing mechanism. In 2011, she will have a paper published in the* ASBC Journal *containing the main results of her research.*

**P-51**
**Beer flavor database**
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The purpose of this work was to identify volatile and non-volatile chemical molecules that contribute to the flavor and aroma of beer, and to create a database for professionals to use in sensory research. Each identified molecule in the database is shown with synonyms, flavor descriptors, typical concentration, formation, compound classification, structure, and molecular weight. In addition, the author identified thresholds, whether it was determined in beer or water, and the flavor units. Separate categories are listed for each of these components. This preliminary work identifies over 700 important molecules that describe flavors in beer. The significance of this for the brewing chemist is to be able to search from a large database of molecules to help find sources of flavors and aromas. Future work will focus on completing the database and examining its relevance for the brewing industry.

*Mark Zunkel completed his B.A. degree at the University of Colorado in Germanic studies and business, studying abroad in both Regensburg and Kassel, Germany. He will receive a B.S. degree from the Technical University of Munich–Weihenstephan in the Brewing and Beverage Department in June 2011. During his studies, he completed internships at Flying Dog Brewery in Denver, CO, and the Forschungsbrauerei in Munich, Germany. During the summer of 2010, he worked with the Research and Development Division of Sierra Nevada Brewing Company. He has been a member of ASBC for three years.*

**P-52**
**Brewing with low-phytate barley malt—Increased mineral availability for improved fermentation**
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Minerals are essential for continuous yeast growth, a requirement for efficient fermentation, and their requirements increase when fermenting worts with high gravity or high levels of adjunct. Availability of minerals can be reduced in barley by phytic acid, or phytate, a chelating agent present in barley, which is involved in binding and precipitation of minerals. Low-phytate barley was originally developed to increase nutritional availability of minerals for humans and farm animals but potential benefits for brewing led to development of a doubled-haploid population from the cross between AC Metcalfe and a reduced-phytate barley mutant. This study determined the impact of brewing with the low-phytate barley malts on wort mineral availability and fermentation performance. Barley from normal and low-phytate doubled-haploid bulks, based on bulk segregant analysis, and parents were grown in multiple locations during each of two growing seasons. Malts made from regular and reduced-phytate barley were brewed in a 3-hL brewery using maltose syrup as adjunct, to bring the starting gravity to 14°P. The worts and resulting beers were analyzed for minerals using atomic absorption spectroscopy. Acidity and pH were also measured to determine the effect of changes in free phosphate ions on buffering capacity of wort. Average levels of zinc increased from 0.1 ppm in normal worts to 0.3 ppm in low-phytate worts. Magnesium levels also increased on average from 125 to 135 ppm. Zinc and magnesium are both necessary for yeast growth, and can be limiting to fermentation. While no differences were found in the levels of copper between low- and normal-phytate worts, iron levels did increase from 0.1 to 0.3 ppm. Elevated levels of iron can have a negative effect on flavor and foam stability. Acidity and buffering capacity of worts were unaffected by the low-phytate trait, despite the anticipated increase in free phosphate ions. Increased fermentation efficiency was demonstrated in the pilot brewery and also in laboratory-scale testing. Adjunct fermentations with low-phytate malt used more zinc, and achieved better attenuation than malt with normal phytate levels. Low-phytate lines are being pursued for release as commercial malt barley varieties.

*Aaron MacLeod joined the Canadian Grain Commission in 2005 and is currently a chemist in the Applied Barley Unit of the Grain Research Laboratory. The unit provides quality assurance for malting barley grown in western Canada and conducts research on factors affecting malting barley quality and measurement methods. Aaron holds a B.S. degree in chemistry from the University of Western Ontario and has been a member of ASBC since 2008. He has participated in the collaborative study of numerous methods and is currently the chair of two technical subcommittees. Aaron is also the secretary of the Canadian Prairie Section of AACC International.*

**P-53**
**Comparison of fluorescence methods for determining yeast viability using a novel automated image-based cell counting and viability system**
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Yeast viability is an important parameter that can affect fermentation performance in a brewery, which can dictate the quality of the end product. Traditional methods for determining viability involve either counting cultured yeast colonies on agar or counting methylene blue-stained yeast cells using a hemacytometer and a microscope. Faster and more robust technologies such as flow cytometry or absorbance plate readers involve the use of fluorescent staining rather than colorimetric stains. Although standard practices, the traditional methods have some advantages but also some well-recognized drawbacks. The hemacytometer and microscope are an image-based technology, which allows counting of single or chain-forming yeasts, but they are labor intensive and prone to human error when evaluating multiple samples. Flow cytometry is an automated and high-throughput cell-counting technology, but it cannot be used for chain-forming yeasts. Previous comparative studies have shown discrepancies in determining the appropriate yeast viability staining assay, which may be due to the differences and drawbacks of traditional and flow cytometry analysis technologies. Here, we present a recently developed platform for bright field and fluorescence image-based cell counting and viability measurements that allow for direct comparisons between different fluorescent staining methods without the previously mentioned limitations of manual counting and flow cytometry. The system performs automated cell counting, which reduces assay time and is more objective, allowing for higher throughput analysis and more robust results. In addition, the imaging capability allows declustering of chain-forming yeasts, which improves the accuracy of the results in the presence of cellular aggregates. This system was used to compare three fluorescent viability stains: bis-(1,3-dibutylbarbituric acid) trimethine oxonol (DiBAC4(3), oxonol), propidium iodide (PI), and the magnesium salt of 8-anilino-1-naphthalenesulfonic acid (MgANS) on various yeast samples, which resulted in identical viability determinations for the same sample, in contrast to previous publications. We propose that this platform can be used for studies on different yeast strains and various culture conditions to determine the robustness of various staining methods with the goal of establishing a standard, optimized method for yeast viability measurements that is more reliable than the traditional methylene blue stain followed by manual counting.

*Alnoor Pirani received a B.S. degree in molecular genetics and molecular biology from the University of Toronto and a Ph.D. degree in cell and molecular biology from Boston University. He is currently employed at Nexcelom Bioscience as an applications specialist, using his research expertise and product knowledge to assist customers with*

*their cell counting and analysis needs. He is also involved in application development, assisting the R&D team to further develop Nexcelom's product offerings for yeast counting and analysis and a variety of other applications for the brewing, biomedical, and biofuels industries.*

**P-54**

**Degradation rate of marker genomic DNA reveals the inflow time of beer-contaminating insects**

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Insects or insect remains found in beer are one of the major issues in consumer claim. Accurate estimation of inflow time is a critical factor for the settlement of such claims related with beer-contaminating insects but no reliable methods have been developed. In an attempt to establish a molecular marker-based diagnostic method, the degradation rates of 18S rRNA genes in the insects soaked in 500 ml of beer were investigated by quantitative real-time PCR (qPCR) over a one-month period at room temperature. Among the six insect species tested, the house fly (*Musca domestica*) and honey bee (*Apis mellifera*) revealed high correlations ($r^2$ = 0.974–0.990) between the degradation of 18S rRNA gene and inflow time. Experiments using house flies at three different temperatures (4, 25, and 37°C) disclosed that the degradation rate of the 18S rRNA gene was relatively higher at higher temperatures. In these insects, statistically significant distinction was possible between the samples stored in beer less than 7 days and more than 7 days. Other insects, including the fruit fly, common house mosquito, German cockroach, and Indian meal moth, displayed poor correlations, which appeared to be attributed to the inconsistent genomic DNA extraction likely due to small sample size or/and disintegration of body parts during storage in beer. With proper improvement in DNA extraction, this 18S rRNA-based diagnostic method would be applicable for estimating the inflow time of beer-contaminating insects.

*Ki Hyun Myoung received a bachelor's degree in food science technology from Kyunghee University in South Korea. He began employment with Hite brewery in 1993 as an analyst in the analytical laboratory of the Quality Control Center. He moved to the Department of Brewing, and he participated in building a new plant in Kanwon Do in 1997. He moved to the Research & Development Center in 2001 and worked on quality control of brewing and raw materials until 2007. He has attended a six-month intensive course from March 2005 through August 2005 at the Scandinavian School of Brewing, Copenhagen, Denmark; Feldschlosschen, Rheinfelden, Switzerland; Carlsberg Brewery, Northampon, UK; and Carlsberg Brewery Malaysia Berhad, Malaysia, as part of an in-depth process and quality course designed for Hite by the Scandinavian School of Brewing. In 2008 he became the executive general manager in the laboratory of the Research & Development Center.*

**P-55**

**Distilled spirit analysis using an aqueous-stable polyethylene glycol GC stationary phase**

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Distilled spirits are analyzed for compounds called congeners, which are formed during fermentation. These compounds add to the flavor of the final product but can be harmful if consumed in excess. Therefore, monitoring these congeners is very important as it can identify problems with production, refute fraudulent claims, and be an invaluable part of the quality control process. GC using a polyethylene glycol (wax type) phase acquires the best resolution and peak shape for distilled spirit congeners. However, historically, injecting aqueous samples such as distilled spirits on a polyethylene glycol stationary phase cannot be done since water has a very negative affect on stability. This study demonstrates the distilled-spirits congener's GC analysis using a 100% aqueous stable ZB-Waxplus column. By using this column, highly reproducible results were obtained for the analysis of a 60% aqueous Scottish single-malt whiskey.

*Matthew Trass received a B.S. degree in chemistry from the University of Otago in Dunedin, New Zealand. He began employment with Phenomenex in 2006 as an application chemist. With Phenomenex he has developed GC, SPE, and LC methods, as well as conducted training seminars.*

**P-56**

**Effect of serving temperature on the flavor profile of beer**

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We launched a beer to be served at –2°C last summer and received favorable comments. Consumers reported that beer served at –2°C had a greater sensation of carbonation and better foam quality in terms of it being creamy and stable, and clear taste. However, consumers gave a different evaluation of the same beer when it was served at different temperatures. Why? From a physical viewpoint, stronger oral sensation is attributed to higher apparent carbonation, and beer foam composed of smaller and more bubbles will be creamier. Of taste factors, bitterness does not change with temperature, but the intensity of astringency is decreased at –2°C compared to that at 8°C, conferring less astringency and clear taste, making the beer chilled to –2°C easier to drink. As expected, flavor release was reduced at –2°C. Volatile compound composition was analyzed in the headspace of solid-phase microextractions by gas chromatography-mass spectrometry. The amount of volatile compounds extracted at –2°C was significantly lower than that at 8°C. In this study, we focused on the effect of temperature on flavor release in the mouth at –2 and 8°C. A simulation of flavor sensation in the nasal cavity and quantification of the volatile compounds was carried out by a modification of Thomas' method (1991) for breath analysis. The number of volatiles detected at –2°C was lower than that at 8°C, and the intensity of specific odors differed with temperature, with greater concentrations of esters identified as 'fruity' or 'citrus' and lower concentrations of compounds identified as 'sweet' or 'smoky' at –2°C. These findings are consistent with the sensory characteristics reported for the beer served at –2°C and suggest that beer flavor profiles are temperature dependent.

*Tomoko Ishibiki is a researcher at the Research Laboratories of Brewing Technology, Asahi Breweries, Ltd. She graduated from the Department of Home Economics (Dietician course) of Otusma Women's University Junior College in 1995. In the same year, she joined Asahi Breweries, Ltd., working on brewing microbiology in the Department of Brewing Science. From 2001 to 2008, she developed cider and shochu, which is a clear, distilled Japanese spirit, in the Department of Wine and Spirits. In 2009, she transferred to her present section, focusing mainly on the analysis of flavor components.*

**P-57**

**Fermentation with unfermentable sugars to improve the palate fullness and oxidative stability of beer**

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Several breweries use unfermentable sugars to increase the beer palate fullness. Besides the direct addition of sugars to the final beer, it is a standard custom to add these sugars at the end of the wort boiling process prior to fermentation; especially for low-solubility sugars. The aim of this study was to investigate influences of the addition before fermentation of commonly used unfermentable sugars (polydextrose, palatinose, and

trehalulose) in direct comparison to fermentable sugars (glucose and sucrose) on the fermentation process, palate fullness, beer flavor, and $SO_2$ formation. The amount of sugar (fermentable and unfermentable) added to basic wort (10.5% original gravity) was calculated to achieve a realistic increase in final extract of 1, 2, 3, and 5%. Control fermentation with no sugar added (10.5%) and 12% extract was also performed. The fermentations were carried out simultaneously and under the same conditions. Yeast growth, $SO_2$-production, extract, and pH development of every trial was monitored. After fermentation and filtration, the beers were analyzed (viscosity, extract, pH, color, $SO_2$ content, etc.). Additionally, a trained sensory panel tested every trial with special focus on palate fullness, sweetness, and flavor in direct comparison to the control beer where 0% sugar was added (pilsner type). In comparison to the control fermentation, a higher $SO_2$ formation was generally observed in the brews where no sugar was added. Sugar additions (fermentable and unfermentable) up to 1–2% yielded a significant increase in $SO_2$ content. Compared to unfermentable sugars, higher glucose and sucrose additions (>2%) resulted in higher $SO_2$ contents of the finished beers. It seems that the general increase in $SO_2$ is based on the osmotic pressure change in the wort. Besides this, the addition of fermentable sugars leads to a higher $SO_2$ formation because of a stronger increase of the yeast cell number at beginning of fermentation. At higher sugar concentrations (2–5%), the $SO_2$ formation preponderates at the beginning of fermentation during the exponential growth phase of the yeast. This correlation is confirmed by the different influences of unfermentable sugars on the $SO_2$ formation. With respect to the trials with unfermentable sugars, it could be observed that the addition of polydextrose leads to a diminished $SO_2$ formation compared to palatinose and trehalulose mainly due to the smaller influence of polydextrose on the osmotic pressure of the wort. In summary, the results show that the addition of unfermentable sugars to 2% leads to a better palate fullness and higher concentration of antioxidant substances like $SO_2$ without a detectable influence on the beer flavor or sweetness.

*After qualifying as a certified technician in preservation engineering (1991–1993), Thomas Kunz completed his basic studies in chemistry at the University of Applied Sciences, Isny (1994–1995), and his basic studies in food chemistry at Wuppertal University (1995–1998), before starting to study food technology at the University of Applied Sciences, Trier (1998–2002). After graduating, he worked as a chartered engineer in the area of ESR spectroscopy at the Institute of Biophysics at Saarland University (2002–2004). Since 2005, he has been employed as a Ph.D. student at the Research Institute of Brewing Sciences, Berlin Institute of Technology (Technische Universität Berlin). His main research focus lies in analyzing radical reaction mechanisms in beer and other beverages using ESR spectroscopy.*

**P-58**

**Glucose a reducing sugar? Optimized method to ascertain the reduction potential of fermentable and unfermentable sugars in beverages and the brewing process**

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The properties and the mode of action of functional carbohydrates in low-pH beverages such as juice, wine, beer, etc. is becoming more and more a center of attention. The properties of reducing sugars are interesting for shelf life, human nutrition, and the brewing process, especially during wort boiling where sugar reactions are accelerated. During the last decades, various research groups applied different methods to ascertain the reducing potential of sugars. In comparison to the traditional Fehling method, the method according to Chapon and Louis is published (M. Moll, 2001) to be inapplicable for determining the sugars' reducing power. This method describes the reducing power of beverages against a complex of $Fe^{3+}$ with 2′,2′-dipyridyl. Our research work proved that the proposed analytical parameters for the Chapon method—concentration, temperature (20/25°C), and time (300 s)—are unqualified. However, varying different parameters, like temperature (80°C) and concentration, showed that the basic reaction mechanism of the $Fe^{3+}$ reduction is able to differentiate reducing potentials between different sugars in low-pH areas. The functional principle can be used to achieve information about the behavior of sugars at different temperatures and during storage of beverages. In analogy to the accelerating aging trials, an optimized Chapon method using a temperature of 60°C (1 h) was developed. Sugars in low-pH beverages behave differently than the generally known behavior described by Fehling when using NaOH in the Fehling II solution. The applications of the optimized method demonstrate that in a low-pH area (4.2), the strongest reducing potential results from isomaltulose (Palatinose®), followed by fructose, trehalulose (Vitalose®), and maltotriose. Additional investigations using the reaction mechanism according to Fehling ($Cu^{2+}$) in this pH area showed similar results. At low pH, the formation of the open-chain aldehyde structure of glucose is inhibited. In contrast, fructose possesses a higher ability to generate the open-chain structure at low pH resulting in much stronger reducing properties. The results also show that sucrose has a higher reducing potential against $Fe^{3+}$ than glucose. The increasing reducing potential of the "non-reducing sugar" sucrose at low pH can be explained by the acid hydrolyzed formation of invert sugar and the strong reducing potential of the formed fructose. Other investigations at higher temperatures (80/90°C) and higher pH (5.1) give evidence about the behavior of fermentable sugars during wort boiling. Besides the described mode of action of glucose, fructose, and sucrose, the stronger reducing potential of maltotriose against maltose is remarkable. Finally, the optimized Chapon method can be used to support the investigation of the complex reaction mechanism of different sugars in beverages (juice, wine, beer) and the brewing process.

*After qualifying as a certified technician in preservation engineering (1991–1993), Thomas Kunz completed his basic studies in chemistry at the University of Applied Sciences, Isny (1994–1995), and his basic studies in food chemistry at Wuppertal University (1995–1998), before starting to study food technology at the University of Applied Sciences, Trier (1998–2002). After graduating, he worked as a chartered engineer in the area of ESR spectroscopy at the Institute of Biophysics at Saarland University (2002–2004). Since 2005, he has been employed as a Ph.D. student at the Research Institute of Brewing Sciences, Berlin Institute of Technology (Technische Universität Berlin). His main research focus lies in analyzing radical reaction mechanisms in beer and other beverages using ESR spectroscopy.*

**P-59**

**Important synergy role of glutathione (GSH) and catalase in the propagation of yeast *Saccharomyces cerevisiae* under $H_2O_2$ stress**

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Glutathione is an important antioxidant against the toxic effects of $O_2$ and other oxidative compounds; hence, it would be helpful to keep beer flavor when increasing GSH content of brewer's yeast. GSH is synthesized by two sequential reactions in *Saccharomyces cerevisiae* catalyzed by γ-glutamylcysteine synthetase (EC 6.3.2.2) and glutathione synthetase (EC 6.3.2.3), and the GSH1 gene is responsible for coding the former enzyme, which is crucial to GSH synthesis. As a smaller peptide, GSH can be excreted to the outside of the yeast cells. Glutathione can be produced by an enzymatic method and a direct fermentative method. In the latter method, *S. cerevisiae* and *Candida utilis* are currently used to produce glutathione on an industrial scale. Factors

for increasing glutathione production have been investigated. The rates of GSH production of the wild-type strains usually vary from 0.1 to 1%, dry matter. Medium culture conditions, selected yeast strains, and yeast breeding are key factors for increasing the GSH concentration. A nucleophilic center of cysteine is responsible for the high reductive potential of GSH. The role of GSH in redox regulation of gene expression has been described in many studies, highlighting the couple properties of GSH/GSSG and the reduced SH-Group of GSH. It can participate in the regulation of the cell cycle and is an essential reductant during normal metabolism in yeast strains. We investigated the influence of feedstock amino acids, salt, carbon, and nitrogen sources on glutathione production by *S. cerevisiae*. Glucose, yeast extract, oligoelements, and amino acids were found to be suitable feedstock. Highest glutathione production was obtained after cultivation with shaking for 72 h in selective medium and growing conditions. Using this medium, the glutathione concentration increased 3- to 5-fold to 95–110 mg/g of dry matter compared to YM basal medium. The increase of glutathione during the propagation resulted in the protection of the yeast cells against hydrogen peroxide production ($H_2O_2$). In the mean time, the addition of catalase activity during propagation increased the protection of the yeast cells from osmotic and oxidative stresses, demonstrating that these are the major causes of the stress response throughout the process of beer biomass production. In fact, the synergy of glutathione and catalase during the yeast propagation leads to an increase the number of yeast cells produced and causes a positive impact on yeast metabolism.

*Julien Billard is currently a microbiologist in the Research and Development laboratory of AEB Group. He is currently working on the selection of yeast strains for fermentation of beer and specific propagation for expression of MAL and GSH.*

**P-60**

**Improved laboratory performance through the use of UHPLC technology for hop acid analysis**

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Ultra-high-performance liquid chromatography (UHPLC) technology has the potential to decrease the time associated with hop acid analyses and reduce the amount of solvent necessary per analysis, all without compromising chromatographic resolution. UHPLC technology is able to improve chromatographic efficiency and performance by accommodating the high system back pressures associated with the use of high-resolution columns prepared with less than two-micron packing. During this study, hop samples were analyzed using industry accepted HPLC conditions (ASBC Hops-14 and Hops-16) as well as by a method developed for an UHPLC/PDA system (Agilent 1290 UHPLC). The hop samples examined were selected from a range of hop products (cone hops, pellets, extracts) containing α-acids, β-acids, and/or iso-α-acids. No significant differences in α-acid or iso-α-acid analysis were observed when results from HPLC and UHPLC methods were compared. β-Acid results varied between chromatographic methods depending on the type of hop sample analyzed. The results of this study indicate that further work on UHPLC method development for routine hop analysis is justified and should be explored.

*Patrick Jensen received a B.S. degree in chemistry with a specialization in biochemistry from Central Washington University in Ellensburg. After graduation in 2004, he began his employment in the hop industry working in quality assurance laboratories. Since 2009 he has been a laboratory supervisor for John I. Haas Inc. and is responsible for the analytical analysis of hop products. He also teaches analytical and introductory chemistry courses at Heritage University in Toppenish, WA.*

**P-61**

**Improved management of technical beer tasters with a holistically managed solution**

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Current brewery practices of managing technical beer tasters use a distributed system. These distributed systems impede the effective management of technical tasters across the entire brewery structure. This in turn leads to inefficiency and a reduction in performance of the taste panel as well as the introduction of internal processing problems within the brewery structure itself. Running and managing a technical taste panel is a high-input, high-process endeavor, incurring significant costs both financially and with actual manpower. This can take the form of poor allocation of resources (both over- and underestimating resource needs), from the effective identification of the right training for poorly performing tasters to the associated costs incurred by the actual procurement of said resources. The time consumed by these processes can have an undue effect on the control of the taste panel leader over the operation of the group, resulting in a reactive approach to taster management. Analysis of these problems led to a more effective approach to managing technical tasting panels. A managed holistic solution was found to be an effective way of maintaining a technical tasting panel, not just through improvement of results but in the overall administration of the entire process. Every part of the management of a brewery's technical taste panel was taken as a whole and treated as a single system. This single system provided all training and management needs, and introduced a more controlled proactive delivery of taster management through the use of targeted training, proficiency testing, and specialist software. Thresholds were put into place that would indicate if the taste panels required further training with a range of different training solutions. Training would be initiated automatically once these thresholds were reached at a level suitable to maintain the technical tasting panel. The system also eliminated the need to procure resources over an extended period of time. This significantly reduced the amount of input needed from breweries and panel leaders. Panel leaders could focus more effectively on the technical taste panel operation and on achieving results. Furthermore, administration was reduced by eliminating the need to source resources on a frequent basis and the overall cost management was brought under control.

*Ronald Nixdorf is a Dutchman whose career has spanned academia and industry. He started in sensory in 1987 at the Psychological Laboratory of the State University in Utrecht, Holland, where he conducted fundamental and applied research in the area of the chemical senses. Ronald then worked for many years as manager and sensory scientist for the Corporate Sensory Evaluation Department of Heineken R&D in Zoeterwoude, The Netherlands. Since 2005 Ronald has been a key member of the FlavorActiV organization. He has been most active in training tasters and trainers and has implemented sensory technology in breweries all around the world. Today, in addition to being the account manager for some of the largest global brewery groups, Ronald also assists in the development of markets for FlavorActiV across several continents. With customers in more than 170 countries, FlavorActiV is dedicated to helping breweries and beverage producers continuously improve their products through the application of taster training and management systems.*

**P-62**

**Maintaining purchased $CO_2$ beverage gas purity levels to the published ISBT quality guideline limits via multilayer adsorption technology**

DAVID MCMILLAN (1), Jim Tomczyk (2)
(1) Parker Hannifin - domnick hunter; (2) Parker Hannifin - PDF Division

Carbon dioxide ($CO_2$) is used in the brewing industry for carbonation, conveying, packaging, and dispensation. In very large breweries, $CO_2$

can be recovered from the fermentation process; however, the majority of breweries are too small for this process to be cost-effective. Therefore, $CO_2$ must be purchased from an external source. The purchased $CO_2$ is delivered complete with quality certification demonstrating that it meets appropriate specifications. However, the possibility of a quality incident exists from the addition of the beverage gas into the final product. Process contamination can have a serious detrimental impact upon both the flavor and appearance of the beverage (foam head). In recent years, the importance of carbon dioxide quality and its effects on products has been under close scrutiny. Bodies such as the International Society of Beverage Technologists (ISBT) now publish strict quality guidelines for the $CO_2$ used in the beverage industry. Limits are set for moisture, oxygen, carbon monoxide, ammonia, nitrogen monoxide, nitrogen dioxide, non-volatile residue, non-volatile organic residue, total volatile hydrocarbons, acetaldehyde, aromatic hydrocarbon, total sulfur content, and sulfur dioxide among others. In order to address these quality concerns, final multilayer adsorption filtration has been developed to safeguard against introduction of $CO_2$ impurities/contaminants and to maintain the quality of the beverage gas as the supplier intended. Multilayer purifiers are capable of removing these contaminants to extremely low levels, in order to meet stringent ISBT limits for all impurities specified. For example, if there was an aromatic hydrocarbon incident, the multilayer adsorbent technology would have to reduce the contamination to less than 20 ppb vol/vol so the $CO_2$ can still be used within the brewery for its intended purpose. It is well known that contamination can occur in the process after purchasing good-quality $CO_2$; therefore, the whole brewing industry (from large to small) would benefit from final multilayer filtration technology to guarantee full $CO_2$ quality.

*David McMillan is a senior engineering manager for Parker domnick hunter and lives in Newcastle, England. He has worked for more than 20 years in the gas filtration field. In his current role he leads a team of research and development professionals who provide technical solutions in the gas filtration arena. He is a qualified mechanical engineer with numerous professional qualifications, including a BCAS diploma in compressed gas management and is a qualified six sigma black belt through the University of Newcastle.*

**P-63**

**Methods for increasing haze stability in wheat beer**

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The presence of haze (turbidity) in beer is usually an objectionable trait. However, the presence of a strong and persistent haze is normally a distinctive and desirable sensory characteristic in *Hefeweizen* wheat beers. A common dilemma observed in the production of these beers is haze settling during the storage of the product in kegs. Previous research has concluded that the most frequently observed constituents of these hazes are suspended yeast cells and protein-polyphenol complexes. This study analyzed haze suspension stability in order to develop processing modifications that could increase haze intensity and stability. A commercial *Hefeweizen* wheat beer was treated with an assortment of post-production processes and their haze intensity and stability was monitored and compared to untreated control samples. Some of the processes included subjecting the beer to high shear and heating the beer to 90°C. The immediate results of shearing the beer produced a high turbidity that declined with time but retained a higher equilibrium haze value than the control ($P > 0.05$). In addition, a variety of other process modifications to enhance haze stability, including mashing regime, freezing, homogenization, and pasteurization, are currently under investigation. This poster will present the effects of these experimental treatments and the modeling of their haze stability over time. Proposed explanations of these observations will also be presented.

*Joshua Adler received a B.S. degree in biology from Dalhousie University in Halifax, NS, Canada. While pursuing his degree, he became very interested in food science and was the first Dalhousie student to gain a minor in the discipline. His undergraduate thesis focused on problems encountered in wheat beer production, and he is continuing this research as an M.S. candidate. He hopes to contribute innovative research to the science of brewing, as well as pass on valuable knowledge as a teaching assistant for product development and quality assurance courses. A second research interest is the study of beer fermentability he is undertaking as part of a brewing research team at Dalhousie University. When outside the laboratory, Joshua can usually be found in the boxing ring training for an upcoming bout or enjoying a pint with his friends. One of his life's ambitions is to visit as many of the world's brewing and distilling regions as possible. He recently returned from the Lowland Region of Scotland, where he visited a variety of breweries and distilleries.*

**P-64**

**Optimization of wort production for brewing rice malt using commercial enzymes and barley malt**

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Rice has been used in brewing for a long time, but with limited content due to the neutral, empty flavor of rice and its low protein content; therefore, malting of rice grain was proposed as an alternative method to improve flavor and add enzymes for increasing soluble nitrogen. The present experiment aims to increase the rice ratio for lager beer production by using malted rice grain and adding heat-stable α-amylase and nutrease in the wort production step. The response surface methodology (RSM) through face center composite design (CCD) was selected to examine the effects of the four variables: germination time of rice (X1), ratios of rice malt (X2), α-amylase (X3), and protease added content (X4) in three levels. Small-scale mashing of 26 experiments was carried out with mashing temperature programmed as follows: 45°C×10 min, 50°C×60 min, 63°C×40 min, and 95°C×60 min. Germination time of rice, rice malt ratio, amount of α-amylase, and protease were expressed as the independent variables. The analysis of variances indicated that α-amylase was essential for extraction and improved the filtrate volume due to the saccharification activity, whereas bacterial protease and germination time of rice malt were not affected to extract content and filtrate volume when α-amylase was supplemented. Rice malt ratio influenced filtrate volume; 75% rice malt mashed with 0.25 g of malt α-amylase supplement per 100 g illustrated the maximum filtrate volume. Addition of bacterial protease increased the amount of wort FAN. However, germination time of rice demonstrated the most impact on wort FAN. Malt from the fifth day of germination could be mashed at 90% wt/wt with both enzymes at 0.4 g of malt per 100 g and illustrated the appropriate wort for brewing. High rice ratio wort was successfully formulated; therefore, an appropriate yeast strain and fermentation process should be considered in further work.

*Ulaiwan Usansa holds a Ph.D. in biotechnology.*

**P-65**

**Optimized fermentation and maturation with ECO-FERM™**

RUDOLF MICHEL (1), Udo Funk (2)
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For the fermentation and maturation of beer, the responsible brewmaster has access to only a small number of tools to control and optimize the processes: recipe parameters: temperature, pressure, and time; process parameter: gravity of the wort, yeast strain; continuous fermentation and maturation processes; and mixing of the tank The complex mixture of fermenting wort and yeast cells normally reacts very quickly to changes in the temperature and pressure profile or to additional application of "stress," GEA Brewery Systems has developed the system ECO-

FERM™ to improve the performance during fermentation and cooling down to cold maturation temperatures. This provides a process using jet mixing in a cylindroconical tank (CCT). A jet without any movable parts is installed in the cone of a CCT using the Venturi principle. So only one-third of the total flow inside the CCT is pumped around with a circulation pump. Approx. 10% of the carbon dioxide produced during fermentation is dissolved in the beer; the other 90% bubble up to the liquid surface forming a bubble column in the CCT. This bubble column leads to an upward movement of the liquid in the center of the CCT and consequently to a downward movement at the cooled shell of the tank. The jet in the cone provides a powerful support of this natural upward motion. Improvement of this upward flow will keep a bigger number of active yeast cells in suspension and, in addition, yeast cells on their way down to the cone are sucked from the jet and are re-suspended in the fermenting liquid. More yeast cells in motion will speed up the chemical reactions. The hydraulic jet also improves temperature homogeneity in the tank and significantly enhances the heat transfer coefficient at the tank shell. This paper presents the first results from an industrial application in a 2,660-hL CCT with worts of 14°P. For all trails, a wort batch of 5,320 hL was used to avoid differences coming from brewhouse operations. The batch was divided into a tank equipped with ECO-FERM™ and a reference tank using the standard process of the brewery. The results cover process duration and temperature homogeneity as well as analytical results of the beers, including DLG tastings.

*Rudolf Michel received both his engineering degree and his Ph.D. degree from the Technical University of Munich at Weihenstephan, Germany. He was a member of the scientific staff at the Institute of Chemical Engineering at Weihenstephan, working on the mechanisms of hot-break separation in a whirlpool tank and hygienic design of armatures and pipework systems in the food industry. Rudolf's industrial experience includes an apprenticeship as a brewer and maltster at Mahr's Bräu in Bamberg, Germany. He joined GEA Brewery Systems in 2000 as director of brewing and technology and has been involved in major brewing projects and research works around the world for GEA. Currently he is leading the research and development team dealing with improvement of brewing technology and environmental aspects of the brewing industry. He is a member of DBMB and has published more than 64 papers.*

**P-66**

**Optimized hop management to improve the oxidative stability of wort and beer**

THOMAS KUNZ (1), Philip Wietstock (1), Wiebke Hense (1), Frank-Jürgen Methner (1)
(1) Berlin Institute of Technology (TU Berlin), Department of Biotechnology, Chair of Brewing Sciences, Berlin, Germany

The influence of specific hop bitter acids like α-, β-, and iso-α-acids as well as the hop dosage regime on the oxidative stability of wort and beer were evaluated using ESR-spectroscopy, GC-MS, HPLC, and sensory analyses. The addition of hops resulted in significantly higher oxidative stabilities of wort and beer compared to brews where no hops were added. Furthermore, hop α-and β-acids showed similar radical quenching abilities, while iso-α-acids displayed a negligible effect. Consequently, the isomerization of α-acids to iso-α-acids significantly reduced the antioxidant capacity of wort. Compared to a single hop dosage at the beginning of wort boiling, it was possible to increase the concentration of strongly antioxidative α-acids in wort by applying fractional hop dosage regimes while achieving comparable hop bitter yields. The radical generation could be decreased by 15–28% yielding significantly higher oxidative wort stabilities. Based on these results, further investigations were carried out whereby fractional hop dosage regimes were also applied during the whirlpool rest. For compensating lower hop bitter yields, it was necessary to partially preisomerize the used hop extract before adding it. The results clearly demonstrate that the fractional addition of preisomerized hop extracts in the whirlpool leads to a higher content of antioxidative α-acids in the pitching wort. Hence, a lower radical generation can be detected and the wort's oxidative stability increases significantly while comparable bitter units can be achieved. One explanation for this phenomenon may lie in diminished precipitations of hop ingredients during wort boiling and hot trub formation. In conclusion, the ideal stage for adding α-acids to the wort in order to increase the wort's oxidative stability can be found during the whirlpool rest. Considering all results, the fractional later hop dosages, especially during the whirlpool rest, make sense to increase the antioxidant properties of wort and beer. Additionally, in a lot of cases, the higher amount of α-acids in the pitching wort resulted in slightly higher $SO_2$ contents after fermentation. The enhanced $SO_2$ formation may be caused by higher α-acid contents which, in turn, lead to a lower consumption of $SO_2$ by oxidative processes during fermentation.

*After qualifying as a certified technician in preservation engineering (1991–1993), Thomas Kunz completed his basic studies in chemistry at the University of Applied Sciences, Isny (1994–1995), and his basic studies in food chemistry at Wuppertal University (1995–1998), before starting to study food technology at the University of Applied Sciences, Trier (1998–2002). After graduating, he worked as a chartered engineer in the area of ESR spectroscopy at the Institute of Biophysics at Saarland University (2002–2004). Since 2005, he has been employed as a Ph.D. student at the Research Institute of Brewing Sciences, Berlin Institute of Technology (Technische Universität Berlin). His main research focus lies in analyzing radical reaction mechanisms in beer and other beverages using ESR spectroscopy.*

**P-67**

**Overcoming wastewater treatment plant limitations by ballasting the microbial floc**

Steven Woodard (1), BRANDON M. MAYES (2), William J. Yawney (2)
(1) Cambridge Water Technology, Portland, ME; (2) Long Trail Brewing Company, Bridgewater Corners, VT

The Long Trail Brewing Company's wastewater treatment plant was designed to treat high-strength wastewater with a BOD5 concentration of approx. 10,000 mg/L. The original treatment capacity was 500 lb/day of BOD5, and the plant was limited by the performance of the secondary clarifier. As Long Trail's future plans called for increases in production volume that would soon outgrow the brewery's wastewater treatment capacity, a cost-effective solution that could handle the anticipated increase in high-strength brewery waste without overloading the secondary clarifier was needed. A secondary objective was to enhance nitrification and denitrification, to help protect the environment by providing a higher level of nitrogen removal and overall treatment plant stability. Long Trail considered upgrading its existing activated sludge system using membrane bioreactors (MBRs) or high-rate anaerobic treatment technology. The BioMag process was ultimately selected for its cost-effective capability to increase the capacity of the wastewater treatment facility without adding any tankage or expanding the plant's physical footprint. BioMag is a relatively new process that enhances biological treatment systems by using magnetite to ballast, or weigh down, the biological floc. With a specific gravity of 5.2 and a strong affinity for biological solids, magnetite substantially increases the settling rate of the biomass, thereby overcoming the bottleneck in the secondary clarifier. Increasing settling rates of the biological floc provides the opportunity to increase mixed liquor suspended solids (MLSS) concentrations and treat increased hydraulic flows and loadings. The paper discusses the design, implementation, and results of the treatment plant upgrade, including adding the BioMag process and upgrading the nitrogen removal processes.

*Brandon M. Mayes received a B.S. degree in biological sciences from York College of Pennsylvania. He began working for Long Trail Brewing Company in Bridgewater Corners, VT, in 2006 as the assistant quality assurance manager. Brandon is a licensed wastewater and public water systems operator with the state of Vermont. Long Trail Brewing Company*

*is a regional brewery producing approx. 80,000 bbl of beer annually and operates an activated sludge wastewater treatment facility to treat its high-strength brewery waste.*

**P-68**

**Overexpression of MAL and GSH genes with selected hybrid *S. cerevisiae* and induction with a specific maltose-amino acids medium**

JULIEN BILLARD (1), Huu Vang Nguyen (2), Mustapha Nedjma (3)
(1) R&D Department, Spindal AEB Group, Gretz-Armainvilliers, France; (2) INRA, AgroParisTech, Thiverval-Grignon, France; (3) nedjman@aol.com

The development and production of selected beer yeast for fast and complete metabolization of maltose, maltotriose, and glucose, the three main fermentable sugars in wort, has been considered. Maltose, maltotriose, and glucose are the most abundant fermentable sugars in wort; in case of incomplete fermentation, maltotriose can cause a range of qualitative problems in beer and ethanol loss. Fermentation performance was followed through the optimization of the culture medium, reproducing accurately the wort composition by monitoring yeast growth, ethanol synthesis, original gravity and attenuation, and sugar consumption during the fermentation process. Beer flavor was evaluated through the content of higher alcohols, volatile esters, and aroma compounds. Here, we investigated the influence the medium composition on the expression of different MAL genes, especially those encoding the maltose and maltotriose transporters. We tried to correlate the impact of yeast metabolism with beer aroma profile. The equilibrium and reproducibility of the aromatic profiles were also analyzed and compared with traditional yeasts after successive inoculation: mutation, membrane permeability. Flavor expression and stability is generally affected by oxidation during beer processing and storage. In order to improve aroma quality and stability, the GSH1 gene, which encodes g-glutamylcysteine synthetase and glutathione synthetase, an enzyme essential for glutathione (g-glutamyl-L-cysteinyl-glycine) synthesis, is needed. The glutathione is one small peptide that can be excreted from the yeast cells during fermentation. The over-expression of GSH1 in brewer's yeast may improve the GSH content in beer. The glutathione "GSH" is an important antioxidant against the effects of oxygen and other oxidative compounds. This is particularly beneficial to beer flavor protection and stability during beer storage. Accordingly, GSH plays an important role in balancing the redox potentials in different subcellular compartments and maintaining the redox balance in *Saccharomyces cerevisiae*. The effect of the medium containing precursor amino-acids, salts, carbon, and nitrogen sources upon the yield and the productivity of glutathione from the isolated strain of *S. cerevisiae* and the corresponding hybrid were investigated in detail. Another way to exploit the potential of the selected yeast, an interesting solution, is its hybridization with *S. cerevisiae* or *S. uvarum*, by crossing of spores or cells from selected strains. Hybrids constructed in this way, using strains from our collection, showed increasing enzymatic expression thanks to the union of the two parental genomes.

*Julien Billard is currently a microbiologist in the Research and Development laboratory of AEB Group. He is currently working on the selection of yeast strains for fermentation of beer and specific propagation for expression of MAL and GSH.*

**P-69**

**Phenol quality control testing in yeast with gas chromatography**

KARA TAYLOR (1)
(1) White Labs, Inc., San Diego, CA

Typically. non-phenolic brewer's yeast, under the right conditions, should not mutate. Some strains of yeast are more prone to mutation than others and occasionally a non-phenolic brewer's yeast will start producing phenolic off-flavors. Identifying this mutation before pitching is critical. On the other hand, in phenolic producing yeast, the amount of phenolic compounds the yeast produces is related to the cell health and growth rates. These two aspects of brewer's yeast are important for the quality of a final product. One way to compare the levels of phenolics produced by brewer's yeast to determine mutations or yeast health is through gas chromatography. The use of gas chromatography can produce very accurate and precise data of the concentrations of phenols produced by the yeast. By comparing this data, brewer's yeast that has possibly mutated can be assessed without the use of PCR. Phenols of interest are 4-ethylphenol, o-chlorophenol, 4-ethylguaiacol, and 4 vinylguaiacol.

*Kara Taylor graduated from Loyola Marymount University with a B.S. degree in biology. After discovering her passion for beer in college, she quickly became a beer enthusiast and relocated to San Diego, CA. She is a member of San Diego's Quality Ale and Fermentation Fraternity (QUAFF). In her free time she enjoys going to beer festivals, knitting, yoga, and homebrewing.*

**P-70**

**Process improvements at the Ibhayi brewery, South Africa, from using a yeast monitor**

John Carvell (1), BETTIE LODOLO (2), Martin Brookes (2), Clint Viljoen (2)
(1) Aber Instruments, Aberystwyth, U.K.; (2) SABMiller, South Africa

In order to produce consistent fermentation performance and beer quality, it is essential that yeast stocks are managed in such a way that variability in physiological condition is minimal. Providing that this is accomplished and there is adequate control of other important variables such as wort composition and oxygen concentration, fermentation performance is governed in large part, by the yeast pitching rate. It follows that procedures that lead to precise and repeatable control of yeast pitching rate will result in consistent fermentation performance. A yeast monitor (Aber Instruments Ltd., UK) incorporated into an automatic yeast dosing system is the only current workable means of consistently and accurately controlling pitching rate in-line automatically. Breweries that have replaced manual laboratory methods for measuring live yeast cell concentration with automatic pitching rate systems based on a yeast monitor have benefited from much more consistent fermentations. This might be reported as more consistent fermentation rates and times or fewer corrective actions such as beer blending. It follows that any improvements in the consistency of fermentation will result in an improvement in quality of the final beer. In this poster, we report the findings of using a yeast monitor at SAB Ltd. in South Africa. RDF (real degree of fermentation) and ferment rates before and after the installation of the yeast monitor were used as a measure of the success of the installation.

*Elizabeth Lodolo completed her B.S. degree in microbiology, genetics and zoology at the University of Pretoria, and she started her career as a bursar with the CSIR, where she completed her M.S. degree (with distinction). Her studies then focused on yeast and fungal molecular genetics expressing heterologous proteins in yeast and developing rapid molecular tools. She moved to SAB as a microbiologist in 1992, where her investigations focused on fermentation optimization. She received her Ph.D. degree from the University of Stellenbosch for a study titled "The Effects of Oxygen on the Fermentation Ability of S. cerevisiae During High-Gravity Wort Fermentations" and the MBAA Presidential Award for outstanding refereed paper based on this work. She worked as a senior research scientist for SABMiller Global Research, investigating various aspects of propagation optimization, yeast fingerprinting, roles of yeast food (zinc and $CO_2$ toxicity), yeast vitality, yeast handling, flocculation, and microbiological control. She has authored or coauthored 23 papers related to yeast research and brewing science and served as a panel member for the National Research Foundation. She is an affiliated professor at the University of the Free State and, in 2011, was invited to serve on the* ASBC Journal *Editorial Board. Since 2007 she has been the SAB brewing consultant for yeast, fermentation and hygiene in the SAB Ltd. Brewing Centre of Excellence.*

**P-71**

**Quality control method of beer-spoiler's detection media by using microbiological reference material: 2010 BCOJ collaborative study**

BCOJ Analysis Committee (1), YASUO MOTOYAMA (2), Nao Kaneko (2), Satoshi Shimotsu (2), Satomi Naito (2), Takaaki Fujiwara (2), Tomoko Uehara (3), Toshinao Shimabukuro (3), Hiroko Kosugiyama (4), Mitsutaka Sometaya (4), Toshio Fujii (4), Takako Yanagisawa (4), Takeo Ishihara (5), Hajime Kanda (5), Naoto Harakawa (6), Kumiko Matsubara (7), Keiko Togami (8), Chikage Yamamoto (9)
(1) Brewery Convention of Japan, Moriya-shi, Ibaraki, Japan; (2) Asahi Breweries, Ltd., Moriya-shi, Ibaraki, Japan; (3) Orion Breweries, Ltd., Nago, Okinawa, Japan; (4) Kirin Group Office Co. Ltd., Tsurumi-ku, Yokohama-shi, Kanagawa, Japan; (5) Sapporo Breweries, Ltd., Yaizu-shi, Shizuoka, Japan; (6) Sapporo Breweries, Ltd., Hita-shi, Oita, Japan; (7) Suntory Liquors, Ltd., Shimamoto-cho, Mishima-gun, Osaka, Japan; (8) Suntory Business Expert, Ltd., Shimamoto-cho, Mishima-gun, Osaka, Japan; (9) Sysmex Corporation, Nishi-ku, Kobe-shi, Hyogo, Japan

BioBall® is a freeze-dried reference material for quality control of media which contains constant numbers of viable cells. As commercially available products, BioBall® series contain 19 different organisms, such as *Bacillus subtilis*, *Escherichia coli*, *Clostridium sporogenes*, and so on. Recently, BioBall® of *Lactobacillus brevis* DSM6235 strain has been newly developed. In this trial, BioBalls® with four powder media (MRS, Raka-Ray, BMB, and UBA) were sent to each collaborator. Each medium was prepared as per the manufacturer's instructions. BioBall® was spread onto each medium, and CFUs were counted after 7 days of anaerobic cultivation. The results were evaluated according to "basic method for the determination of repeatability and reproducibility of a standard measurement method" in JIS Z 8402 and "design of experiments (ANOVA)" in JIS Z 8101 guidelines. Mandel's *h* and *k*, Cochran's test, and Grubb's test were used in the statistical evaluation of the data to identify outliers. The repeatability relative standard deviation ($RSD^r$) for the detection of CFU by each medium ranged from 6.4 to 8.4%, and the reproducibility relative standard deviation ($RSD_R$) ranged from 7.7 to 13.3%, respectively. The ratio of $S_R$ and $S_r$ (1.2–1.7) is below the empirical threshold of 2.5. Therefore, the $RSD^r$ and the $RSD_R$ were judged acceptable. The comparison of CFU averages among four media using the one-way ANOVA showed no differences at the 5% significance level. From these results, the BCOJ subcommittee recommends that this BioBall® method be suitable for the quality control method of beer-spoiler's detection media and be adopted for inclusion in the BCOJ Microbiology Methods.

*Yasuo Motoyama received a B.S. degree in agricultural chemistry from the Tokyo University of Agriculture and Technology, Japan. He joined Asahi Breweries, Ltd. in 1990. He received a Ph.D. degree from Tokyo University in 2003. Since 2008, he has been working on microbiological quality assurance in breweries and developing detection technology for beer-spoilage microorganisms.*

**P-72**

**Rapid analysis of hop acids in beer using solid-phase extraction and high-performance liquid chromatography**

MATTHEW J. TRASS (1), Phillip Koerner (1), Jeff Layne (1), Sky Countryman (1)
(1) Phenomenex, Torrance, CA

Iso-α-acids, derived from hops, have a significant impact on the taste of all beers. Therefore, monitoring the iso-α-acids profile and content during beer production and in the final product is very important. Using typical methods for analyzing these compounds can result in run times of 15–20 min or longer with undesirable peak shape. In conjunction with a quick and easy solid-phase extraction cleanup method, an improved HPLC method for iso-α-acids in beer is demonstrated using a Kinetex 2.6-µm core-shell column, resulting in improved peak shape, quantitation, and dramatically reduced analysis times.

*Matthew Trass received a B.S. degree in chemistry from the University of Otago in Dunedin, New Zealand. He began employment with Phenomenex in 2006 as an application chemist. With Phenomenex he has developed GC, SPE, and LC methods, as well as conducted training seminars.*

**P-73**

**Review of degassing methods for beer**

BRYAN R. DONALDSON (1)
(1) University of California, Davis, CA

The Society has long had procedures in place for the degassing of beer, starting with the development of Method Beer-1 A in 1958. The step is essential in a multitude of other beer analyses. As such, much work has been done over the past 20 years to find more effective, easier, and faster ways to decarbonate beer samples, without losing the ability to run the subsequent analyses with precision and accuracy. Interestingly, not all of this work has come directly from the brewing industry, but from outside sources studying beer for reasons such as health effects and storage issues. A review of the literature has shown that different analytical procedures will work better with different degassing methods. Identifying the proper method of degassing for each analytical method will allow for more consistent, reportable results, with minimal damage and loss of sample.

*Bryan Donaldson graduated with a B.S. degree in biochemistry from Santa Clara University in 2009. He began graduate school at UC Davis in 2009, pursuing a master's degree in food science, with a focus on beer and brewing, working with Charles Bamforth. During the summer of 2010 he worked as a brewing intern at the Los Angeles brewery of Anheuser Busch-Inbev. He plans to have completed his degree by June 2011.*

**P-74**

**Routine microbiology with PCR—What's new?**

GUDRUN J. VOGESER (2), Corina R. Nuber (1)
(1) Georg-Simon-Ohm Hochschule Nürnberg, University of Applied Sciences, Nürnberg, Germany; (2) PIKA Weihenstephan GmbH, Pfaffenhofen, Germany

Brewing microbiology is still known to generate results which are available typically way later than desirable for production needs. The traditional analyses are more or less still the same as they were 200 years ago: enrichment and visual inspection for microbial growth. In the past 15 years, different approaches have been made to use molecular biology, mainly detection of genetic material (DNA), for the fast and specific detection of spoiling microorganisms. The results of those analyses such as polymerase chain reaction (PCR) are generally accepted, but the method itself has not yet reached every brewer's lab. The general opinion is that PCR analysis is too complicated to be used in a mid-sized brewery. This study compares traditional microbiological methods in a brewer's lab involving conventional enrichment methods with results from real-time PCR. Comparison includes reliability of methods, time from sample to result, as well as practical aspects like handling and cost. A special focus lies on the necessities and possibilities for implementation of PCR analysis into small and medium-sized breweries which require a low-budget system with minimal operator intervention. Examples from PCR applications in small breweries are shown as well as the variation of beer-spoiling microorganisms monitored over some years. The composition of the microbial flora and changes in their composition within particular breweries and beer types are evaluated.

*Gudrun Vogeser received a diploma in microbiology from Eberhard Karls University in Tuebingen, Germany, and afterward worked at the Technical University of Munich, Germany, where she finished her doctoral thesis in 1992. She was then employed as a scientist at the Chair of Brewing Technology at TU Munich–Weihenstephan, where she examined the use*

*of molecular biology methods, mainly PCR, to detect and analyze beer-spoiling microorganisms. In 2000 she founded PIKA Weihenstephan, Pfaffenhofen, where she is working as a managing partner. Gudrun is a founding member and, since 2009, chair of the European Brewery Convention (EBC) Microbiology Committee.*

**P-75**

**The effective use of propylene glycol-based secondary refrigerants**

KEVIN CONNOR (1)
(1) Dow Chemical, Midland, MI

The ability to accurately control temperature throughout the brewing process plays a critical part in producing high-quality beer with desirable and reproducible flavor characteristics. Often a secondary refrigerant such as propylene glycol is used along with a non-ozone-depleting primary refrigerant like ammonia to provide necessary cooling. The food grade status of propylene glycol makes it an attractive secondary refrigerant, particularly in the event of accidental spills or leaks, and solutions with water are non-flammable, have low environmental impact, and provide effective heat transfer down to temperatures as low as 0°F. When propylene glycol is properly formulated to include suitable corrosion inhibitors, long-term corrosion protection of pipes, pumps, tanks, and chillers is readily achievable. However, poorly formulated or badly neglected propylene glycol-based secondary refrigerants are more corrosive than plain water and can also contribute to other problems such as a build-up of mineral scales, bio-film fouling, decreased pump performance, and inefficient heat transfer. Most of these problems don't happen overnight and in fact are not normally noticed until they reach a point where they can affect cooling capacity, which in turn affects production and/or product quality. By then, the problem has caused irreversible damage which can only be corrected by shutting down the refrigeration system to replace the fluid and to clean, repair, or replace damaged system components. Avoiding the pitfalls of improper selection and operation of propylene glycol-based secondary refrigerants is not difficult and it can contribute towards lower operating costs and help avoid costly shutdowns. A "how-to" guide and review of effective practice for propylene glycol-based secondary refrigerants is presented.

*Kevin Connor received his B.S. degree in chemistry from the University of Waterloo (Canada) in 1985. He has worked for The Dow Chemical Company for 25 years and is currently a senior development specialist responsible for technical support of the DOWTHERM™ and DOWFROST™ inhibited glycol heat-transfer fluids product line. Kevin has been a member of ASHRAE for the past 10 years and currently serves as a voting member for TC 3.1 Refrigerants and Secondary Coolants. He is married and has two children ages 16 and 18.*

# Scholarship and Award Recipients

Every year ASBC recognizes those who show outstanding promise, have contributed valuable research to the industry, or have enhanced the brewing industry with their contributions. Congratulations and thanks to this year's recipients.

## 2011–2012 ASBC Foundation Scholarships

Scholarships are supported by individual and corporate donations made throughout the year. Thank you to everybody who supported the Foundation this year. If you are interested in supporting the foundation, donations can be made at http://www.asbcnet.org/foundation..

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## Award of Distinction

*Charlie Bamforth*

Charlie Bamforth is the recipient of the 2011 Award of Distinction. This award acknowledges exceptional lifetime achievement, contribution, and service to brewing science and the brewing industry. Recipients of this award receive an engraved plaque and $1,000 honorarium.

## 2011 Eric Kneen Memorial Award Recipients

The winners of the 2011 ASBC Eric Kneen Memorial Award are Cynthia Edelen, Robert Foster, and Eric Samp, for their article, "Influence of Cardiolipin on Lager Beer Dimethyl Sulfide Levels: A Possible Role Involving Mitochondria?" The article was published in the *Journal of the American Society of Brewing Chemists* (Vol. 68, No. 4, pp. 204-209).

The ASBC Eric Kneen Memorial Award is presented to the author(s) of the best paper published in the *Journal of the American Society of Brewing Chemists* during the previous calendar year. The Awards Committee is composed of the ASBC Journal's Editor-in-Chief, the Editorial Board, and the Technical Committee. The team will receive $1,000, and each person will receive an engraved plaque.

*Cynthia Edelen*

*Robert Foster*

*Eric Samp*

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Thank you to all of the volunteers who help make ASBC a valuable society. And, a very special thank you to the Program Committee that made this meeting possible and to the officers, committee chairs, and section chairs who pull everything together.

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# WBC


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